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An Inquiry into the Causes of the Decay of Wood, and the Means of preventing it. By CHARLES H. PARRY, *M. D.*

(Concluded from page 309.)

WHEN wood decays under cover, that condition is usually called the dry-rot. Let us examine the circumstances in which this change takes place.

It affects the interior doors, shelves, laths which subdivide the layers of wine, and all other wood work in certain cellars; beams and rafters which support the roofs of close passages; joists laying on or near the earth; the wainscoting of large rooms, little inhabited, in old and especially single houses; and wood in various other situations of a similar kind, which need not be particularized. In some of these cases, while one sample or portion of wood shall suffer the dry-rot, another specimen or portion shall remain unchanged. In other instances, wood of various kinds and qualities has been successively employed, and all has alike suffered. During the stages of change, a crop of mucor or mould, and

very frequently of fungi, has sprung from the porous mass; and the decay is always attended with a wide-spreading exhalation, the odour of which cannot well be described, but which is sufficiently known.

What then are the causes of this destruction? Precisely the same as those which I have before described; though their action is differently modified, and less obvious to gross observation. The decay is produced by the putrefactive fermentation of the component parts of the wood, in connection with moisture, without which, as I have before stated, wood cannot putrefy.

Common air is not only capable of mixing with a considerable quantity of water in form of vapour, but during every state of our atmosphere is always much loaded with it. Water becomes vapour in consequence of being united with a certain proportion of that substance which is called heat. If a sufficiently cold substance comes into contact with vapour, the superabundant heat, which was necessary to its existence in that form, passes into that cold substance, and the vapour is then immediately condensed or changed into water. Thus if in the hottest day in summer, when the vapour in our breath is totally invisible, we breathe on a looking-glass or plate of polished metal, which is colder than our breath, the surface is immediately dimmed; and if we continue to breathe on it, small drops of liquid appear, which gradually become larger and larger, and many of them at length uniting, run down the surface in a stream. The same thing takes place on the outside of a glass of water drawn in summer from a deep well, and of a bottle brought up into a warm room out of a cool cellar; and on the inside of our windows in frosty weather. On the other hand, we could not dim with our breath a plate of metal or glass of one hundred degrees of heat, which is greater than that of our breath, and no mist is observable

on the inside of our windows during the heat of a summer's day; nor is there any condensation of moisture on the outside of a glass of cold water fresh drawn from the well, or of a bottle out of a cellar, when either is brought into the open frosty air.

These circumstances will explain many appearances, by which, for want of due examination, we are often greatly puzzled. We are frequently mortified by seeing in our houses, especially in the country, the walls become stained, or the paper separated and hanging down, and often perishing; and as this usually happens on the side or corner which is most exposed to the weather, we conclude that the damp comes through the wall, and tax our faculties to the utmost, in order to prevent this penetration. The measures which we employ sometimes succeed. But it often happens, that casing, and plaistering, and painting the devoted angle fails; and then, as the last resource, we take off the paper and attach it to canvass at the distance of one or more inches from the wall, and thus, for the present at least, effect the desired purpose. Now in this case it is just as absurd to suppose, that the wet comes through the wall, as that it comes through the glass window in a frosty day, or the glass or bottle from the well or cellar. The fact is, that in an exposed house, and more especially on the most exposed corner of a room seldom warmed by fire, the inner surface of the wall, by the continuance of frost, is become of a very low temperature, like the air within the room itself. So long as this state of equal temperature between the wall and internal air continues, or if the wall is warmer than that air, it is obvious that the vapour which is mixed with the air cannot part with any heat to the wall, and therefore will not undergo condensation; just as no dampness appears on our windows during a hot day in summer. But if a thaw comes on, and the air

becomes warmer than the wall, which, from its capacity of easily shifting place, it will readily do, then the vapour, which is mixed with it, parts with its superabundant heat to the colder wall, and appears on it in moisture or drops, or pours down it in streams; just as happens to the cold bottle brought into the warm dining-room.

This change is the greater, the more completely the materials of the wall fit it for carrying the heat out of the vapour, or, in philosophical language, the better they conduct heat. Hence a wall painted in oil condenses vapour, or runs with water, sooner than one, which, being unpainted, is more porous; for which reason, in cities, we first perceive dampness and drops or streamlets of water on the oil-painted party walls which bound our staircases, and which are, therefore, absurdly said to sweat, though these walls have no communication with the outward air, and, from their varnished covering, cannot admit of the passage of moisture or perspiration through their pores.

In this case the remedy is obvious, and by its success shows the nature of the evil. Prevent your walls from ever becoming colder than the warmest external air of winter, and you will never have this appearance of damp on their inner surfaces.

This may be done, first, by constructing the walls of such a degree of thickness, or with such a disposition or quality of materials, that they shall not, in the usual way, be greatly cooled throughout their whole substance by any temperature of the outward air. With this view, I think that in all single hours, which are not warmed by neighbouring fires, and more especially in situations exposed to high winds, and therefore to great evaporation from the external surface, and consequent abstraction of heat, the walls should always be double, having on the

inside a thin layer of brick, with an interval of one or two inches from the outer and thicker layer of brick or stone, to which it must be united by proper binders. The porous structure of the bricks, added to the impermeableness of the intermediate stratum of air, would so ill conduct heat, that such walls would necessarily tend to keep a house dry and warm in the winter, as well as cool in the summer. This end would be still further promoted by filling the interval between the two layers with dry sand, fresh sifted coal-ashes, or powdered charcoal. In fact, when the common external means before described have succeeded in curing dampness, it has been either by affording a varnish, which has diminished evaporation by preventing absorption, or by increasing the space or changing the quality of the materials of the wall through which the heat was to pass, so as in either of these cases to retain it more forcibly: And when the dampness has been remedied by removing the paper to some distance from the wall by means of strained canvass, that effect has been produced by rendering the paper a worse conductor of heat; and therefore indisposing it to condense the vapour in the room so readily as when it was in contact with the colder wall.

It has been suggested, that it would be possible to keep out cold, or, in more accurate language, prevent the egress of heat from the inside of a room, and therefore from the walls surrounding it, by shutting it closely up, and preventing any admission of the cold external air. This has arisen from the supposition that air is not a good conductor or transmitter of heat through its substance or pores, but that it merely carries it by changing place with some other portion which was less charged with it. If there were no other mode of abstracting the heat from the walls of a room, and if it were possible wholly to prevent any change of its air, this theory might perhaps

apply. But it is not possible to prevent some exchange of this kind through the atmosphere of any habitable chamber; and it is evident from the moisture being most abundantly, or perhaps solely, deposited on the inside of that part of the wall which is most exposed to the external cold, that the chief or common mode in which the wall is cooled is not by the access of the cold air into the room, but by the passage of heat from the wall itself into the cold air without. We may however so far avail ourselves of this principle, as to exclude as much cold air as we can, by shutting up the windows and chimnies of uninhabited rooms during the severity of frost.

It may farther be suggested, that as, during a thaw, the air, being warmer than in frost, has a greater quantity of water in form of vapour mixed with it, shutting up a room on such occasions may, by retarding the admission of warmer air so charged with vapour, allow time for the walls to acquire an equable temperature through their substance from without, so as to anticipate any condensation on their surface which might occur from the free admission of the external air. To this I only answer, as before, that rooms according to the common construction cannot be excluded from communication with the external air; and that, in fact, the dampness does under these circumstances take place, though the doors and windows are never opened.

In all cases, however, there is one method of preventing this species of dampness, which is infallible; and that is to keep every part of the internal surface of the wall in the chamber or staircase sufficiently warm by good fires. With this view all staircases ought to have some means of receiving artificial warmth.

If, notwithstanding this and the former precaution, a wall should accidentally become damp, the next best ex-

pedient is to dry it as quickly as possible by a free current of warm air.

This discussion, which at first sight might appear tedious and irrelevant, will, I trust, no longer be thought so, when it shall have been found necessary for the establishment of a principle on the subject more immediately before us.

In order to show the analogy, let us take the simplest example, which is that of a wainscotted room, unwarmed by fires. When the wainscot is colder than the air, it condenses the vapour in form of moisture. If that moisture were exposed to the influence of the sun and wind, the case would come under the former head of decay, which is that of wood wetted by rain in the open air. The water soon evaporates, and little decay proceeds in the wood. So in the wainscot, the surface next the room, though unprotected by paint, will perhaps be long in rotting, because the room admits of currents of air, more especially when doors and windows are frequently opened, so as to evaporate the superficial moisture, though less quickly and effectually than in the open air. But what is the case with the surface of the pannel next the wall? The air, loaded with moisture, penetrates into that interstitial space, and deposits it by condensation on that surface. But there is afterward no current of air to evaporate the water so deposited, which then slowly decomposes and destroys that surface of the pannel. Such is precisely the process of the dry rot, which always begins next the wall, and gradually proceeds to the painted or outer surface of the wood. It resembles in its chief circumstances the decay of paper in a damp room; and it precisely resembles that of paper projecting from the wall on canvass, which will still often happen, if the wall be subject to acquire a very considerable degree of coldness, though much more slowly than in the former case.

The same process obtains in all other cases. Whenever the wood is cooler than the air which it touches, the vapour is condensed upon it; and being exposed to no new heat or current of air sufficient again to evaporate it, remains till another fit of condensation affords a new supply.

Thus the process of corrosion and decomposition is continually supported till the wood moulders away.

The term dry-rot is, therefore, so far from being expressive of the real fact, that decay proceeds under these circumstances more quickly than in the open air, precisely because the wood is more constantly and uniformly wet; just as the lower parts of posts and rails, and any cavities in timber exposed to the weather, rot sooner than those parts which readily and speedily dry.

The smell which we perceive on going into vaults or cellars, where this process is going on, arises partly from the extrication of certain gases, mingled perhaps with some volatile oil, and partly from the effluvia of those vegetable substances, which have already been said to grow on it; and which, though they begin merely because the decayed wood is their proper soil, yet afterward tend probably to the more speedy decomposition of the wood itself. They cannot, however, with more propriety be said to be the cause of the dry-rot, than the white clover, which appears on certain lands after a top-dressing of coal-ashes, can be said to have produced the soil on which it flourished.

I have remarked above, that sometimes only a particular sort or sample of timber has in certain situations rotted, while another piece has continued for a great length of time perfectly sound. Hence persons have been deceived, and been disposed to attribute the dry-rot solely and universally to some original peculiarity in the wood itself. Dr. Darwin explains this fact by telling us,

that the wood so decaying has probably been cut in the spring, when the sap in the alburnum was not only abundant, but of a saccharine quality; which, in combination with the vegeto-animal substance or gluten, disposes it to run with unusual readiness into destructive fermentation. In some trees, as by more particular custom the oak, the bark is a very valuable article of commerce, and is found not only to quit the tree more readily, but to contain a larger proportion of tan in the spring, when the sap is rising, than at other seasons. Hence an old act of Parliament, now in force, ordains that all oak, except for the purpose of building, shall be felled in the spring. Whether doors, posts and rails, paling, barrel staves, &c. come under the denomination of building, it may be difficult to say; but it seems at first view highly to be lamented, that any law should impose an obligation to destroy a valuable species of property. It would indeed be matter of peculiar regret, if an impolitic and avaricious spirit should induce the owners of oak forests to extend the same principle to the timber employed in the construction of great machines, and more especially the British navy.

Various means have been employed in order to remove the tendency to the dry-rot in trees so felled. Thus they have been long exposed to the rain, or steeped, or even sometimes boiled in water, and then dried by artificial heat. These means do not however appear to have been successful in entirely washing out the fermentible sap, which therefore makes them much more subject to the decay of which we are treating. It may however still be doubted, whether it acts in any other way than by furnishing a disposition, which requires to be called into action by the same cause which operates in all other cases, moisture.

In proof of what I have stated, I have been informed by one of our vice presidents, that in a large vat or set of vats for beer, belonging to him, the staves formed of oak two inches and a half thick, notwithstanding they were previously steeped in hot water, and then thoroughly dried, in a very short time underwent the dry rot, while others in the same situation continued unchanged five or ten times that period. It is highly worthy of remark, that the outside of these staves, which was painted, continued sound, and that the decay began on the inside, where, from the vats being at different times more or less filled, they were snbject to the joint and successive influence of moisture and air.

I have mentioned above, that the putrefactive fermentation cannot take place except in certain temperatures, the lowest of which, according to Thomson, must be but little below 45 degrees of Fahrenheit's thermometer, and the highest within the degree which produces dryness, by evaporation. The temperature most conducive to this effect has not, so far as I know, been ascertained, though much useful information on this head might be obtained from a set of well conducted experiments.

The following then appears to be the whole theory of the dry-rot; that it is a more or less rapid decomposition of the substance of wood, from moisture deposited on it by condensation, to the action of which it is more disposed in certain situations than in others; and that this moisture operates most quickly on wood which most abounds with the saccharine or fermentible principles of the sap. Let us see how this theory corresponds with the best known means of prevention, and what more effectual measures it may suggest.

The first point is certainly to choose timber properly felled and well dried. And here, in order to prevent the injudicious fall of large oak timber, it may be of some

consequence to know, that the bark of such timber contains much less tan than that of the younger and more succulent wood; and that this principle, together with the proper extractive matter, is considerably more abundant in the bark of the Leicester or Huntingdon willow, than in that of any oak. According to the experiments of Mr. Davy, seven pounds and a half of the former will go as far in tanning leather as nine or ten pounds of the latter. It has however been asserted, that if an oak, or any other tree, which is stripped of its bark, be suffered to stand two or three years before it is felled, the wood will have acquired a very great degree of strength and durability.

Next, where it is practicable, a current of air should be frequently made to pass along the surface of the wood. This expedient seems to have been particularly attended to by the ingenious architects of our Gothic churches, who are said with that view to have left various openings in the walls between the two roofs of those edifices. In order also to promote evaporation, a certain degree of heat, such as that of air heated by the sun or fire, should, if possible, be from time to time applied. Cellars themselves ought to have some communication with the outward air by means of windows and shutters, or trap-doors. And that these may be for a short time opened in proper weather, so as to have a draught of air, and that no very low degree of temperature is necessary for the preservation of fermented liquors, provided that temperature be uniform, is evident from the practicability of keeping wine extremely well in cellars which are not damp, and in which, therefore, one or both of these circumstances must have taken place.

The destruction of wainscotting may be long deferred by keeping in the apartment suitable fires.

Lastly, the dry-rot may in all cases be infallibly prevented where it is practicable to cover the surface of the

wood, properly dried, with a varnish which is impenetrable and indestructible by water. With this view two or three coats of the composition before described should be laid on the dry wood, before it is erected or put together, and a third or fourth after it is put in its place; and proper means should be taken thoroughly to dry each successive coat of varnish. In situations of this kind, what means of preservation are necessary must be employed at first; as it seems scarcely possible to renew them on fixed timber with any chance of benefit.

I do not know whether in very damp situations, surrounded with stagnant air, these varnishes would in time admit of the growth of fungi or mould. The brimstone might be sufficient to preclude that effect; but, if we believe Braconnot, seeds of the white mustard sown in pure flowers of brimstone, and well watered, became vigorous plants, which flowered and produced effective seed. It is certain, however, that the essential oil of turpentine will act as a poison on growing vegetables; and perhaps the same property may exist in resin, which seems to be a similar essential oil, united with a certain proportion of oxigen.

It is however highly probable, that the union of the brimstone may have another good effect, which is to prevent one of the causes of the destruction of timber which I have before mentioned, the depredations of insects. Whoever would learn the havoc, which certain animals of this kind are capable of making in hot countries, would do well to read Smeathman's description of the termes, or white ant, originally published in the Philosophical Transactions, and thence abridged into the English Encyclopedia Britannica, and other collections. In this country we know little of such ravages. Mischief however of this kind does sometimes occur, and may be the work of various animals, a particular account of which

may be met with in the fifth volume of the Transactions of the Linnæan Society.

I am informed, that in India, a circle of lord Dundonald's coal tar drawn on the floor round boxes and other furniture, will effectually preserve them and their contents from the depredations of the white ant.

It appears, that most insects are fond of sugar and mucilage; which is the probable reason why that wood is most subject to be penetrated by worms, which is felled when it most abounds with sap. In such cases, it might be well to try the effects of washing the wood, previously to the use of the varnish, with a solution of arsenic in hot water, in the proportion of one pound to ten gallons; or with a strong decoction of coloquintida or bitter apple, or white hellebore; after which the wood must be completely dried before the application of the varnish in the manner before directed. All these preparations are extremely cheap, and are either destructive or offensive to insects, and therefore will, probably, be an effectual defence against any injury from that cause.

C. H. Parry.

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No. 65.

On the Edulcoration of Fish-Oil. By Robert Dossie, *Esquire.**

Explanation of the Principles on which the Purification of Fish-Oil may be performed, and of the Uses to which it is applicable.

THAT the fœtid smell of fish-oil is chiefly owing to putrefaction, it is unnecessary to show; but, though this

* Tilloch, vol. 15, p. 105. From the *Transactions of the Society for the Encouragement of Arts, &c.* vol. xx.—So far back as the year 1761 the Society voted him a bounty of one hundred pounds for this communication, though they did not publish it till 1802.

be the principal cause, there is another likewise, which is, ustion, or burning the oil, occasioned by the strong heat employed for the extracting it from the blubber of the larger fish, and which produces a strong empyreumatic scent that is not always to be equally removed by the same means as the putrid smell, but remains sometimes very prevalent after that is taken away.

In order to the perfect edulcoration of oils there are consequently two kinds of fœtor or stink to be removed; viz. the putrid, and the empyreumatic: and the same means do not always equally avail against both.

The putrid smell of fish-oil is of two kinds: the rancid, which is peculiar to oils; and the common putrid smell, which is the general effect of the putrefaction of animal fluids, or of the vascular solids, when commixed with aqueous fluids.

Fish-oil has not only rancidity, or the first kind of putrid smells peculiar to oils, but also the second or general kinds; as the oil, for the most part, is commixed with the gelatinous humour common to all animals, and some kinds with a proportion of the bile likewise; and those humours putrefying combine their putrid scent with the rancidity of the oil, and, in cases where great heat has been used, with that and the empyreuma also.

The reason of the presence of the gelatinous fluid in fish-oil is this: that the blubber, which consists partly of adipose vesicles, and partly of the membrana cellulosa, which contains the gelatinous fluid, is, for the most part, kept a considerable time before the oil is separated from it, either from the want of convenient opportunities to extract the oil, or in order to the obtaining a larger proportion; as the putrid effervescence which then comes on, rupturing the vesicles, makes the blubber yield a greater quantity of oil than could be extracted before such change was produced; and the vesicles of the tela cellulosa, con-

taining the gelatinous matter, being also burst from the same cause, such matter being then rendered saponaceous by the putrefaction, a part of it mixes intimately with the oil, and constitutes it a compound of the proper oleaginous parts and this heterogeneous fluid.

The presence of the bile in fish-oil is occasioned by its being, in many cases, extracted from the liver of the fish; which is not to be so profitably done by other means as by putrefaction; and the bile being consequently discharged, together with the oil from the vessels of the liver containing them, combines with it, both from the original saponaceous property of bile, and from that which it acquires by putrefaction.

This holds good particularly of the cod-oil, or common train, brought from Newfoundland, which, from its high yellow colour, viscid consistence, and repugnance to burning well in lamps, manifests sensibly the presence of bile and the gelatinous fluid; which latter, by the saponaceous power of the bile, is commixed in a greater proportion in this than in any other kind of fish-oil.

A tendency to putrefy, or at most but in an extremely slow manner, is not an absolute property of perfect oils in a simple or pure state, but it is a relative property dependent upon their accidental contact or commixture with the aqueous fluid. This is evident from the case of oils concreted into a sebaceous form; which being perfectly oleaginous and uncombined with any water, except such as enters into their component parts, will not putrefy unless water, or something containing it, is brought into contact with them. But the fluid animal and most vegetable oils being compounded of perfect oils with other mixed substances, either sub-oleaginous or gelatinous, have always a putrescence *per se*, or tendency to putrefy, without further admixture of aqueous moisture. This commixture of heterogeneous matter in fish-oil, particularly of

the gelatinous fluid and bile, gives rise to a further principle of purification than *simple edulcoration*, or the removing the fœtor: for the presence of such humours in the oil renders it subject to a second putrescence *per se*, supposing the first corrected; makes it unfit for the purpose of the woollen manufacture, as the heat through which this is in some cases employed causes this matter to contract a most disagreeable empyreuma. It also prevents its burning in lamps, as well from its viscidity as from the repugnance which the presence of water gives to all oleaginous matter. It is therefore necessary to free the oil from this heterogeneous matter; after which it can be subject only to the rancid putrescence, or that which is proper to oils as such.

The substances which have been or may be applied to the removing or preventing the effects of putrescence, are, acids, alkalies, metallic calces, neutral salts, ethereal and essential oils, vinous spirits, water, and air. With respect to acids, though they may be applied with effect to the removal or prevention of putrefaction in mixed animal and vegetable substances, yet they have not the same efficacy when employed in the case of oils; for in a small proportion, without the subsequent aid of alkalies, they rather increase than diminish the fœtor, and in a large proportion they coagulate the oils, and change their other properties as well as their consistence. Though they might therefore be employed with the assistance of alkalies, yet, requiring a more expensive and complex process, and not being moreover necessary, as the same end may be obtained by the use of alkalies only, they may be deemed improper for the purification of animal oils for commercial purposes. Alkaline substances, both salts and earths, are the most powerful instruments in the edulcoration of oils; but as their action on putrid oils, and the method of applying them to this end,

are not the same in both, it is proper to consider them distinctly.

Of alkaline salts it is the fixed kind only which are proper to be used for the edulcoration of oils. Fixed alkaline salts, in a dissolved state, being commixed with putrefying animal substances, appear to combine with the putrid matter, and, mixing with some of the principles, form instantly volatile alkaline salts. On the less putrid they seem to act, after their combination, by an acceleration of the putrescent action, till they attain the degree which produces volatile salts. This is evident by the sensible putrid ferment and smell which appear after their commixture; but which gradually abating, the oil is rendered sweeter, much lighter coloured, and thinner.

Their great use in the edulcoration of fish-oil arises therefore from their converting such parts of the gelatinous fluid and bile as are highly putrefied instantly into volatile salts, and causing a rapid putrefaction of the other parts; by which means the oil is freed from them by their dissipation. They do not, however, equally act on the parts of the oil on which the empyreumatic scent depends, unless by the assistance of heat: for when they are commixed with the oils without heat, in proportion as the putrid smell diminishes, that becomes more sensibly prevalent. The ultimate action of lixiviate salts on animal oils, except with respect to the empyreuma, seems to be the same either with or without the medium of heat; for the same urinous and putrid smell, gradual diminution of the colour, and fœtid scent, happens in one case as in the other, except with regard to the acceleration of the changes; and such salts, where the purification is required to be made in a great degree, are a necessary means, as they are more effectual than any other substance that can be employed.

The use of lixiviate salts alone is not, however, the most expedient method that can be pursued for the edulcoration of oils, for several reasons. If they be used alone, cold, in the requisite proportions, they coagulate a considerable part of the oil, which will not again separate from them under a very great length of time; and when they have destroyed the putrid scent, a strong bitter empyreumatic smell remains. The same inconvenience, with relation to the coagulation of part of the oil, results when they are used alone with heat. The superaddition of common salt (which resolves the coagulum and counteracts the saponaceous power of the lixiviate salt, by which the oil and water are made to combine) is therefore necessary; and the expense arising from the larger proportion of lixiviate salt requires it to be employed if no other alkali be taken in aid, and renders the junction of alkaline earths with it extremely proper in the edulcoration of oils for commercial uses. Lime has also an edulcorative power on animal oils; but it has also so strong a coagulative action, that the addition of a large proportion of alkaline salts becomes, when it is used, necessary to reduce the concreted oil to a fluid state; and therefore this substance alone is not proper for that purpose. The combination of lixiviate salt with lime, or the solution commonly called soap-lye, has an effectual edulcorative action on fœtid oils; but it makes a troublesome coagulation of part of the oil if no common salt be employed, and must be used in such large proportion, if no alkaline earth be added, as renders the method too expensive.

Lime has a power of combining with and absorbing the putrid parts of the gelatinous fluid and bile when commixed with oil, and effects, either with or without heat, a considerable edulcoration of fœtid oils; but it combines so strongly with them, either cold or hot, that the

separation is difficult to be effected even with the addition of brine; and the oil, when a large proportion of it is used, can scarcely be at all brought from its concreted to a fluid state but by an equivalent large proportion of lixiviate salt: the use of lime, therefore, alone is improper, or even in a great proportion with other ingredients. But when only a lesser degree of edulcoration is required, a moderate quantity, conjoined with an equal or greater weight of chalk, which assists its separation from the oil, may, on account of its great cheapness, be employed very advantageously: it will in this case admit of precipitation from the oil by the addition of brine. It may be also expediently used when lixiviate salt is employed with heat for the most perfect purification of oils; for it will in that case give room for the diminishing of the quantity of lixiviate salt, though the proportion be nevertheless so restrained as not to exceed what the proportion of lixiviate salt (just requisite for the edulcoration) can separate from the oil.

Chalk has an absorbing power similar to lime, but in a less degree, on the putrid substance of oil: it does not, however, combine so strongly with the oil as to resist separation in the same manner, and is therefore very proper to be conjoined either with lixiviate salts or lime, as it renders a less quantity of either sufficient, and indeed contributes to the separation of the oil from them.

Magnesia alba, or the alkaline earth, which is the basis of the sal catharticus, and the singular earth which is the basis of alum, both have an edulcorating power on fœtid oils, but like lime, have too strong an attraction with them to be separated so as to admit of the reduction of the oil from the concreted state to which they reduce it; and therefore, as they are not superior in efficacy to lime and chalk, but much dearer or more difficult to be obtained, they may be rejected from the number of ingre-

dients that are proper for the purifying of oils, with a view to commercial advantages.

Sea salt has an antiseptic power on the mixed solid parts of animals; but used alone, or dissolved in water, it does not appear to lessen the putrid fœtor of oils, but, on the contrary, rather increases it. If after their commixture with it they are subjected to heat, it rather depraves than improves the oils; but though by its own immediate action on them it conduces so little to the edulcoration of oils, yet it is a medium for the separation of water and the alkaline substances requisite to be employed to that end. It is of great utility in the edulcorative processes; for when alkaline salts or earths combine with the water necessary to their action on the oils, or themselves form coagulums or corrections with it, a solution of salt will loosen the bond and dissolve the close union; so that the oil being separated will float on the aqueous fluid, while the earth, if any be in the mixture, will be precipitated and sink close together to the bottom of the containing vessel.

Sal catharticus, glauber salt, nitrum vitriolatum, tartar, and other neutral salts, though they counteract putrefaction in the mixed or solid parts of animals, seem to have little effect on oils with respect to their edulcoration, and cannot therefore be ranked amongst the substances proper to be used for that purpose.

Lead reduced to the state of a calx, either in the form of minium or litharge, has a strong edulcorative power on fœtid oils, and is indeed applied to that end, with respect to one kind of vegetable oil, for a very bad purpose, considering its malignant qualities on the human body.

In the case of train-oil, which will scarcely ever be considered among the esculent kinds in this country, the same objection against its use would not lie; and employ-

ed either with or without heat, it is a powerful absorbent both of the putrid and empyreumatic parts that occasion the fœtor.

As, however, there may be some prejudice against its use even in any way, and as it is not absolutely necessary, I have not given it a place among the ingredients of the processes I recommend.

The ochrous earth of iron, commonly called red ochre, has an absorbing power on the putrid parts of oil, but combines so strongly that the separation is tedious even with the addition of brine: if, nevertheless, it is added when chalk and lime have been some time commixed with the oil, as in process the first, it will promote the edulcorative intention, and will subside along with them; and, as it has some advantage without increasing the expense, unless in the most inconsiderable degree, its use may be expediently admitted in that process.

Essential and ethereal oils are applicable to the prevention of putrefaction in the mixed and solid parts of vegetables, but are not so to the edulcoration of fœtid oils; and if they had the desired effect, they would not, on account of their price, answer the commercial end, unless the due effect was produced by adding them to the oils in a very small quantity.

The same holds good of spirits of wine as of essential and ethereal oils, both with respect to their efficacy and the expense.

Water has an edulcorative action on fœtid oils by carrying off the most putrid parts of the gelatinous fluid or bile, in which, as was above explained, the principal fœtor resides, if the quantity added be large, and an intimate commixture be made of them by stirring them together for a considerable time: this only partially removing those heterogeneous putrescent substances, the remaining

part soon acquires the same state, and the oil again grows fœtid, though not to the same degree as before.

Water is, however, a necessary medium for the action of salts and the separation of alkaline earths and calces of metals when they are employed for the edulcoration of oils, as will appear from a consideration of my processes.

Air edulcorates oil by carrying off the most putrid parts, which are necessarily extremely volatile. It may be made to act on them either by simple exposure of them to it with a large extent of surface, or by forcing it through them by means of ventilators, as has been practised by some dealers; but is now, I believe, neglected on account of their finding the improvement of oils by it not adequate to the trouble, as the gelatinous matter and bile, not reduced to a certain degree of putrefaction, being left behind, putrefy again to nearly the same degree as before.

It appears from these several observations, that the cheapest ingredients which can be used for the edulcoration of train-oils are lime and chalk, which may, with the addition of a proper quantity of solution of sea salt or brine, be made to procure a separation of them from the oils, according to process the first, so as to answer for some purposes; that the lixiviate salt is the most powerful purifier of oils, and, with the assistance of chalk and brine, will, without heat, according to process the second, effect a very considerable degree of edulcoration; and that lixiviate salt used with heat, with the addition of lime and chalk, to save a part of the quantity which would otherwise be necessary, and of brine to procure a quick separation, will perform an edulcoration sufficient for all commercial purposes, according to process the third; but that calcined lead and the ochrous earth of iron

may, perhaps, be applied in some cases with advantage, where the oil is not designed for esculent use.

PROCESS THE FIRST.

For Purifying Fish-Oil in a moderate Degree, and at a very little Expense.

TAKE an ounce of chalk in powder, and half an ounce of lime slaked by exposure to the air; put them into a gallon of stinking oil, and, having mixed them well together by stirring, add half a pint of water, and mix that also with them by the same means. When they have stood an hour or two, repeat the stirring, and continue the same treatment at convenient intervals for two or three days; after which superadd a pint and a half of water in which an ounce of salt is dissolved, and mix them as the other ingredients, repeating the stirring, as before, for a day or two. Let the whole then stand at rest, and the water will sink below the oil, and the chalk subside in it to the bottom of the vessel. The oil will become clear, be of a lighter colour, and have considerably less smell; but will not be purified in a manner equal to what is effected by the other processes below given; though, as this is done with the expense of only one ounce of salt, it may be practised advantageously for many purposes, especially as a preparation for the next method, the operation of which will be thereby facilitated.

PROCESS THE SECOND.

To Purify, to a great Degree, Fish-Oil without Heat.

TAKE a gallon of crude stinking oil, or rather such as has been prepared as above mentioned, and add to it an ounce of powdered chalk; stir them well together several times, as in the preceding process, and, after they

have been mixed some hours, or a whole day, add an ounce of pearl-ashes dissolved in four ounces of water, and repeat the stirring as before. After they have been so treated for some hours, put in a pint of water in which two ounces of salt are dissolved, and proceed as before: the oil and brine will separate on standing some days, and the oil will be greatly improved both in smell and colour. Where a greater purity is required, the quantity of pearl-ashes must be increased, and the time before the addition of the salt and water prolonged.

If the same operation is repeated several times, diminishing each time the quantity of ingredients one half, the oil may be brought to a very light colour, and rendered equally sweet in smell with the common spermaceti oil.

By this process the cod-oil may be made to burn; and, when it is so putrid as not to be fit for any use, either alone or mixed, it may be so corrected by the first part of the process as to be equal to that commonly sold: but where this process is practised in the case of such putrid oil, use half an ounce of chalk and half an ounce of lime.

PROCESS THE THIRD.

To purify Fish-Oil with the Assistance of Heat, where the greatest Purity is required, and particularly for the Woollen Manufacture.

Take a gallon of crude stinking oil, and mix with it a quarter of an ounce of powdered chalk, a quarter of an ounce of lime slaked in the air, and half a pint of water; stir them together, and, when they have stood some hours, add a pint of water and two ounces of pearl-ashes, and place them over a fire that will just keep them simmering, till the oil appears of a light amber colour, and has lost all smell, except a hot, greasy, soap-like scent.

Then superadd half a pint of water in which an ounce of salt has been dissolved; and having boiled them half an hour, pour them into a proper vessel, and let them stand till the separation of the oil, water, and lime be made, as in the preceding process. Where this operation is performed to prepare oil for the woollen manufacture, the salt may be omitted; but the separation of the lime from the oil will be slower, and a longer boiling will be necessary.

If the oil be required yet more pure, treat it, after it is separated from the water, &c. according to the second process, with an ounce of chalk, a quarter of an ounce of pearl-ashes, and half an ounce of salt.

Observations on Process the First.

This process may be performed on any kind of fish or seal-oil that is putrid and stinking, and will improve it in smell, and generally render the colour lighter, if previously dark and brown: it will also conduce to render these oils fitter for burning, which are, in their crude state, faulty in that point; but it will not meliorate them to the full degree they admit of even without heat, and should therefore be practised when only a moderate improvement is required.

Secondly, When the oil is taken off from the dregs and brine, the dregs which swim on the brine should be taken off it also, and put into another vessel of a deep form; and on standing, particularly if fresh water be added and stirred with them, nearly the whole remaining part of the oil will separate from the foulness; or, to save this trouble, the dregs, when taken off, may be put to any future quantity of oil that is to be edulcorated by this method, which will answer the same purpose.

Observations on Process the Third.

First, This is most advantageously performed on train-oil, called vicious whale-oil; and the more putrid and foul it may be, the greater will be the proportionable improvement, especially if there be no mixture of the other kinds of fish-oils, particularly the seal, which do not admit of being edulcorated perfectly by means of heat, but require other methods: but when the vicious oil is pure from admixture of others, however stinking it may be, the bad smell will be removed by this process duly executed, and the brown colour changed to a very light amber; and these qualities will be much more permanent in this than in any crude oil, as it will not, from the degree of purity to which it is brought, be subject to putrefy again under a great length of time, whether it be kept open or in close vessels.

The oil in this state will burn away without leaving the least remains of foulness in the lamp; and, being rendered more fluid than before, will go further, when used in the woollen manufacture, than any other kind, and will be much more easily scoured from the wool.

If, nevertheless, there be any branches of the woollen manufacture which require the use of a more thick and unctuous oil, this may be rendered so by the addition of a proper quantity of tallow or fat, of which a certain proportion will perfectly incorporate with the oil, the fluidity and transparency being still preserved, as well as all the other qualities that render it suitable to the intended purpose. This may be most beneficially done by adding a proper quantity of the refuse grease of families, commonly called kitchen stuff, which being put to the oil, when moderately heated, will immediately dissolve in it, and let fall also its impurities or foulness to the bottom of the

vessel, and render the purified admixture a considerable saving to the manufacturers.

Secondly, The different qualities and dispositions of different parcels of vicious oil with respect to edulcoration render various proportions necessary of the ingredients to be used. The quantities stated in the above process are the least which will effect the end in general, and frequently greater will be required; but this may always be first tried: and if it be found, after six or eight hours simmering of the mixture, that no gradual improvement is making in the smell and colour, but that the oil continues the same in those particulars, and remains also mixed with the chalk and lime, and in a thick turbid state, a fourth or third part of the first quantity of pearl-ashes should be added, and the simmering continued till the oil be perfect. As the quantity of the water is lessened by the evaporation, it is necessary to make fresh additions from time to time, that there may be always nearly the original proportion.

Thirdly, If it be inconvenient to give the whole time of boiling at once, the fire may be suffered to go out and be rekindled at any distance of time; and if, in such case, a small proportion of pearl-ashes dissolved in water be added, and the mixture several times stirred betwixt the times of boiling, it will facilitate the operation. The time of boiling may be also much shortened, if the chalk, lime, and pearl-ashes, be added for some days before, and the mixture frequently stirred.

PROCESS THE FOURTH,

Which may be practised alone instead of Process the First, as it will edulcorate and purify Fish-Oil to a considerable Degree, so as to answer most Purposes, and for Process the Third, when the whole is performed.

TAKE a gallon of crude stinking oil, and put to it a pint of water poured off from two ounces of lime slaked in

the air; let them stand together, and stir them up several times for the first twenty-four hours; then let them stand a day, and the lime-water will sink below the oil, which must be carefully separated from them. Take this oil, if not sufficiently purified for your purpose, and treat it as directed in Process the Third, diminishing the quantity of pearl-ashes to one ounce, and omitting the lime and chalk.*

ROBERT DOSSIE.

No. 67.

On the Purification of Rapeseed Oil. By C. THENARD.†

TO purify oil of rapeseed, mix one hundred parts of the oil with from one and a half to two parts of sulphuric acid, and stir the mixture. The oil will immediately change its colour; it will become turbid and assume a blackish-green tint, and at the end of three quarters of an hour it will be full of flakes. You must then give over stirring it, and add gradually double its weight of water to remove the sulphuric acid, which, if allowed to remain too long with the oil, would not fail to exercise too strong an action on it, and to char it. The mixture must then be beat for at least half an hour, to bring the moleculæ of the oil, the acid, and water, into contact with each other; after which it is to be left at rest.

When it has rested about eight days, the oil will float on the surface of the water, and the latter will itself float on a black matter, precipitated from the oil by the sul-

* The dregs remaining after the sundry processes above mentioned will form an excellent manure, as has been since noticed in Dr. Hunter's Georgical Essays.

† Tilloch, vol. 10, p. 68. From the *Journal de Physique*, Floreal, an. 9.

phuric acid: it is this matter which colours the oil, and prevents it from burning with facility. Three very distinct strata, then, are established, as is here seen: the upper one is oil; the second is aqueous, and contains a little sulphuric acid; and the third is carbonaceous. The oil which forms the upper stratum, after these eight days of rest, is far from being limpid: twenty days, in my opinion, would be necessary for it to purify itself merely by repose; but by filtration it may be immediately obtained perfectly clear and transparent. For this purpose, pounded charcoal, and a piece of linen or cotton cloth, may be employed: the two last substances are preferable to any other. The same cloth will serve several times, only it must be carefully cleaned.

By following this process with attention, you may obtain oil which has much less colour, odour, and taste, than that commonly used; which will burn with the greatest facility, and without any residuum; and which is equal to the purest oil sold in the shops, &c. The loss is very inconsiderable.

If you are desirous of obtaining it still purer, it may be exposed again to the same treatment; but, in that case, for one hundred parts of oil, one hundredth part of concentrated sulphuric acid will be sufficient. The sulphuric acid will not form in oil which has been once purified a blackish precipitate; on the contrary, it produces a very scanty precipitate, of a grayish-white colour. This precipitate is more difficult to be separated than the former.

When the oil has been treated with two hundredth parts of sulphuric acid, if it be suffered to digest for twenty-four hours with the fourth of its weight of chalk or carbonate of lime, or of argil, you will obtain it almost as clear as water. Lime, however, cannot be employed with advantage, as it would occasion too much

waste; but, in my opinion, argil would give very advantageous results: it retains, indeed, a pretty large quantity of oil, but, by means of a press, the last portions of the oil may be extracted from the argil almost entirely.

No. 68.

Plan for an improved Theatre. By Sir GEORGE CAYLEY, *Bart.**

(With an engraving.)

Brompton, September 25, 1808.

SIR—Since the lamentable accident, that has so lately happened to the Covent Garden Theatre, the frequent occurrence of that event to my thoughts has led me to speculate upon the various improvements, that might be made in the construction of theatres. I have taken the liberty of enclosing you the following plan and hints, which I conceive to be worthy your attention, inasmuch as they state undoubted principles, which local convenience may more or less permit to be put in practice, but without an attention to which no theatre can be pronounced well constructed. The science of acoustics is perfectly well understood, and the enclosed rough sketch of the internal plan and elevation of a theatre is modified to the principles of that science, in conjunction with giving the greatest possible convenience of sight to the largest number of people the space can contain.

It is the property of an elliptical room, to collect all the sound uttered in one of its foci into the opposite focus by reflection; hence, as the ellipsis is a very beautiful curve, and as it is only the parts of a theatre distant from the stage, that require the aid of reflected sound, I have adopted this figure, as the ground plan, plate 10, fig. 1, will

* Nicholson, vol. 22, p. 243.

show. Here any voice uttered upon the stage at A would be concentrated at the point B, excepting what is absorbed by entering the side boxes.

I have drawn the stage semicircular, and on one side arranged the seats concentrical with it. This, I conceive, would be a material benefit to the observers, but it would have this objection, namely, that the seats, if so placed, must rise in steps and have arms to each; hence the necessary allowance of room for the accommodation of the largest persons would be more than necessary for smaller ones; and on no occasion, however pressing, could the advantage be taken of sitting closer.

I have also drawn the scenery in a portion of a circle, which would be a most material advantage, both to the hearing and sight, *if conveniently practicable:* and provided double the height of a scene can be had within the building, it might be managed by suspending the scenes on cords passing over rollers disposed in this form.

In constructing the elevation of a theatre, the first consideration is to economise space, hence in the boxes, as at No. 1, fig. 2, after allowing the seats to rise one foot in five for the purpose of clearing the view from the heads of those below, if a line be drawn to the top of the scenery from the eye of the most backward observer, the bottom of the next tier of boxes must just commence at that line, as exhibited by dots.

As it is advantageous in the metropolis to make theatres more extensive than the direct voice of an actor can fill with ease, it becomes necessary, to call in the aid of reflected sound, and so to distribute the whole voice as may be deemed most important. I have in the enclosed sketch supposed, that (in a theatre where the extreme part of a pit is one hundred and twenty feet from the centre of the stage) the direct voice is sufficient till within one fourth of the extremity of the building. There-

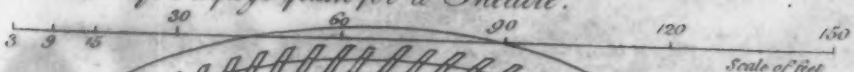
fore, the roof is so curved, as to commence its reflection at that point, as may be traced by following the progress of the pulses of sound emitted by the actor at A. One half the roof, as far as C, is allowed to give the sound it receives over this portion of the pit, and the three tiers of boxes. The remaining half of the roof is employed in throwing its sound upon the upper gallery, increasing the density of its reflection as the distance from the stage increases. Although this gallery receives the influence of half the ceiling, yet from the oblique position of it, it will not catch more than half as much sound as the other portion, which is fully required by the distance of the hind part of the gallery, the direct sound being there twenty-five times less dense than in the quarter of the pit next the stage; whereas by the reflection this disproportion will be reduced to about ten times only, and of course it will be as distinctly heard as in the third quarter of the pit.

The ratio of sound in the three front boxes compared with that of the first quarter of the pit, is as one sixteenth to one; this, by the reflection of half the roof will be reduced to about one seventh, hence these parts will hear nearly as well as the centre of the pit. In addition to this, the back of each tier of boxes should be covered so as to give a focus of sound either to the front, middle, or last benches, as thought best, this shown at 1, 2, 3. The two latter were altered from the former by dotted coves. The fronts to the boxes should present reflecting curves, to throw their sound within the fourth region of the pit.

Fig. 3 is a hind view, showing the proper curve of the roof in this position, where the only object is to keep the diverging rays of sound parallel after reflection, and clear of the sides of the boxes.

I think it would not be particularly expensive to have the whole beam and pillar work of the theatre of cast

Sir G. Cayley's plan for a Theatre.



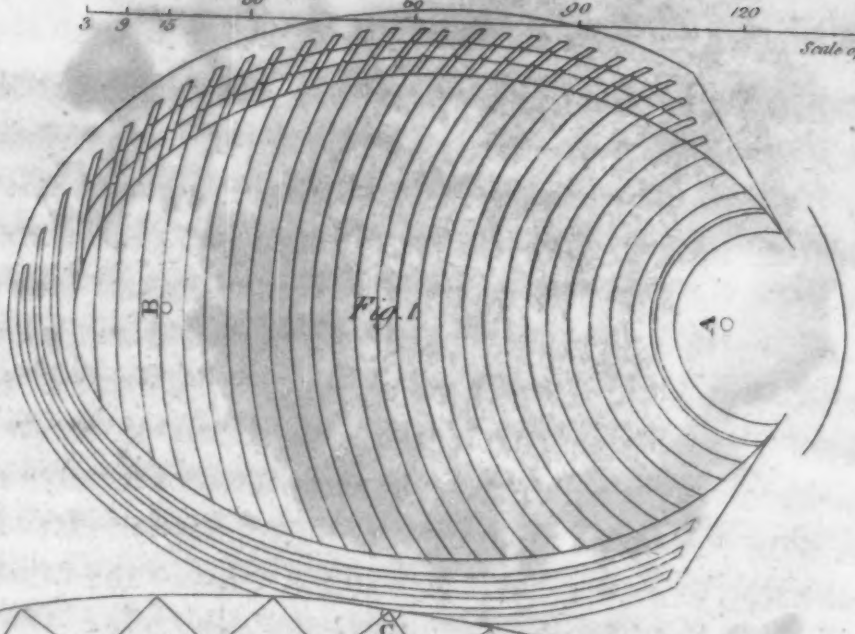


Fig. 1.

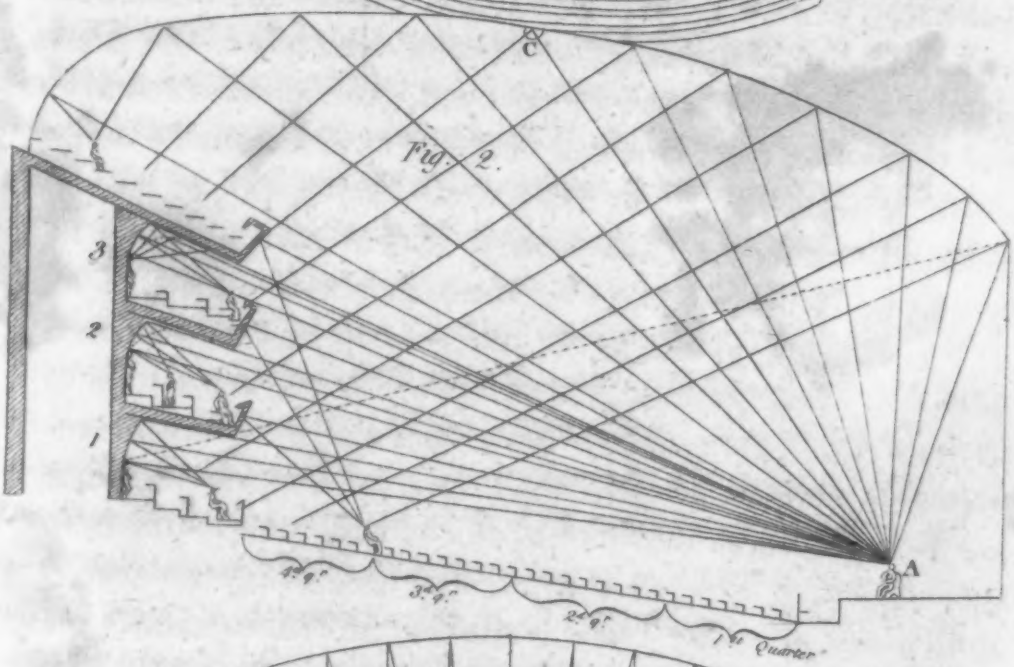


Fig. 2.

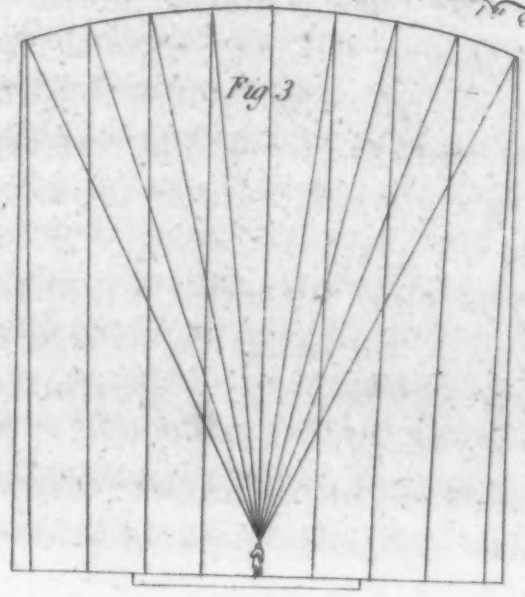


Fig. 3

Emporium of Arts & Sciences Vol. 2. Pl. 10.

iron; and likewise to make the elliptical part capable of being completely cut off from any fire in the other part of the building, by a jointed sheet iron curtain, to close up the stage every night after performance, or in case of fire, during the play hours. The name of this would be very attractive.

To prevent the bad effect of squeezing from sudden alarms, *no door about a theatre should open inwards*, and the outlets should be as large as possible, and some extra ones easily opened if necessary: a good reservoir of water, and an engine or two on the spot, are precautions too obvious to need an observation. I am, &c.

GEORGE CAYLEY.

To JOHN KEMBLE, Esquire.

NO. 69.

On the Construction of Theatres. By RICHARD LOVELL EDGEWORTH, *Esquire, F. R. S. &c.**

Edgeworthstown, March 6, 1809.

SIR—The public, by the loss of two theatres in one winter, must be anxious about the plans on which those edifices are to be rebuilt; they will not be satisfied with the opinion of a single architect, they will require an open discussion of the principles, and plans upon which a new theatre is to be constructed; this they have a just right to demand, for their lives and properties are at stake. Every family in London might have mourned the loss of some relative, had the play-houses been filled at the time of the accident; and the whole city might have been burned to ashes by either of the conflagrations.

We are to consider not only the loss of lives by the immediate disaster, but also the apprehensions, which the audience must feel for some time to come; and the anxie-

* Nicholson, vol. 23, p. 129.

ty, which those who remain at home must suffer during the absence of their friends at the theatre. Nothing should be left to embitter the cup of innocent pleasure, and "assurance should be made doubly sure," where great hazards are run, from no greater motive than the hope of an hour's amusement.

Covent-garden playhouse is now rebuilding without any previous appeal to the public, that I have heard of, as to the plan or precautions, that are to be followed in its construction. I know, that some hints were sent on these subjects, which were not even considered, at least not noticed, till after the plan was arranged. Surely it must be infinitely more advantageous to the proprietors and to the nation, that a short delay should take place before a plan is ultimately arranged, than that a new theatre should be opened ten days sooner, or ten days later.

The glaring defect, or to speak more properly, the obvious blunder in the building of Drury-lane theatre, was the introduction of timber as a frame work for bricks and stone; this is a fault common to buildings in London, where the public safety is without hesitation sacrificed to the interests of individuals.—But to construct a wooden theatre is an absurdity too gross, to pass without animadversion. A frame-work of timber, filled with cores of brick or stone, and cased perhaps with brick or plaister, is opened for the reception of the public, who are to run the risk of sudden destruction from a spark of fire, or a snuff of candle, from the fireworks and lightning of comedy and tragedy, of pantomime and farce, without any probable means of escape, or any security, except what a few hogsheads of water in a cistern on the top of the house can afford.—No future prologue at the opening of a new theatre could re-assure the audience upon this subject.

From a view of these considerations I hope it will appear incumbent upon those, who rebuild Drury-lane, to take time for receiving information from every quarter whence it may be expected: instead of hurrying forward to a beginning before they have well considered the end. A remarkable observation made by that great engineer Mr. Smeaton, in his account of the building of the Eddystone lighthouse, should never be forgotten by those who direct, or by those who undertake extensive public works.—"No resolution of the proprietors," says he, "ever conduced more to ultimate success, than their leaving me at liberty *(as to time)*: had they been of the same temper and disposition as by far the greatest part of those who have employed me, both before and since, their language would have been, *Get on, get on, for God's sake get on*, the public is in expectation, get us something speedily, *to show*, that we may gain credit with the public."

Architects and engineers are so nearly connected with each other in the objects of their pursuits, that it would be well both for them and for the public, if every architect were an engineer, and every engineer an architect. That this is not always the case, we have melancholy instances to prove.

There is a society of civil engineers in London, of which sir Joseph Banks is president, consisting of men of undisputed talents and information. Would it not be advisable, to consult this board? No harm could possibly arise from such application, and much good might be the consequence. If in the multitude of counsellors there may be some delay, there is probably much safety.

Having now animadverted upon the steps that should be taken, before any plan is ultimately settled, I shall venture to offer a few hints upon the construction of a theatre. If any thing, which I throw out, should become

an object of discussion, I trust that I may have an opportunity of explaining what I propose; and if any thing be adopted from my suggestions, that it may not be followed, without my being acquainted with the mode of execution. Many new attempts fail of their object by the introduction of additional ideas, that appear plausible; or by the omission of small circumstances, that seem in the original plan to be of no material consequence.

In building a theatre,

1. Security to the audience is the first and most necessary object.
2. Facility of ingress and egress.
3. Facility of seeing and hearing.
4. Convenience to the performers.
5. Space for scenes, with proper openings for the machinery.
6. And lastly, expense.

1. *To ensure safety*, common sense points out, that as little timber and as small a portion as possible of combustible materials should be employed. The outside walls should be constructed of stone—the coins of large blocks of stone closely jointed, depending upon their own bearings and not made apparently compact by mortar. Bricks for the internal structure should be made under proper inspection, and not worked hastily up, to fulfil a contract. All the joists, rafters, and principals, and the framework of the partitions should be iron. The frame work of the roof should be of the same metal, with a covering of copper. No plumber should be permitted to exercise his dangerous trade in the construction of any part of the building.

It may at first sight appear, that the substitution of iron for timber must be enormously expensive—and it would be enormous, if scientific care were not taken, to calculate the stress and strength of every part of the struc-

ture where iron was to be used, and to frame the material together upon mechanical principles of strength and lightness.

As to the roof, it could no doubt be made lighter and cheaper of iron than of timber at the present price of that material. Cotton mills are frequently floored with hollow bricks, which are light; and these may be covered with carpetting.

Many other parts of the theatre might be constructed of iron and copper; and stucco might be introduced in many places instead of wood. There are kinds of timber that do not flame; these, though not very durable, might be employed for floors and benches. And where deal is absolutely necessary, it may be covered or imbued with a wash, that in some degree will retard inflammation. After the wood work that requires painting has received two coats of oil paint, it may be finished with a coat in distemper, which may frequently be renewed at small expense, and without the disagreeable smell of oil paint.

To heat the green room, dressing rooms, and the withdrawing rooms, steam might be advantageously employed; and the boiler to supply the steam should be so placed, as to serve at a moment's warning, to work a steam engine of force sufficient to draw water at once from the Thames, and to drive it with a strong impulse wherever it should be wanted. This steam engine should be strongly enclosed in a building, to which access on every side could be easily obtained.

2. Some of the theatres at Paris have commodious avenues; but not one theatre in London has been so placed, or so constructed, as to afford tolerable convenience either to the higher or lower class of spectators.

Private property intervenes so much, that it is scarcely to be expected, that any great improvement can be made in this respect, by enlarging the area round the site of the late building.

Whether a more convenient situation might be selected, I do not pretend to know; but a theatre built on the old foundation might be rendered extremely commodious as to its entrances, or *vomitories*, as the ancients called the avenues to their amphitheatres.

If the whole building were raised upon arches of a height sufficient to admit carriages, and if numerous flights of stairs were constructed within the piers which support these arches, the audience might depart commodiously in different directions, without confusion or delay.

The collonades formed by pillars properly disposed, would permit alternate rows of carriages. Company might descend from the boxes almost immediately into their carriages: passages for those who are on foot might be railed off, and rendered secure.

This plan would be attended with considerable expense; but it might be counterbalanced by sparing one of the higher galleries, which lately injured the *audibility* of the performance, without adding much to the profits of the house. Besides it might be so managed, that tickets for the admission of carriages under the *piazzas* should be issued, which would cover the expense of their construction.

3. *Facility of seeing and hearing.*—As to seeing I believe that very little can be said, but what is obvious to every person of common sense; the actors and the spectators have in this respect opposite interests. It is the interest of the actors, to have that part of the house, which contains the audience, as large as possible. On the contrary it must be the wish of the audience, within certain

bounds, to be near the stage; and in all cases, the audience must wish, that every part of the pit, galleries, and boxes, should be equally commodious for seeing. Now in a large theatre this is impossible. To extend the pit and boxes, they must recede from the front of the stage; they cannot be extended in breadth without shutting out the view from the side boxes.

Little inconvenience was felt as to seeing at Drury-lane; but every body, who wished to hear, complained. As to the actors, to make any impression, they were obliged to raise their voices above the natural pitch; to substitute pantomimic gesticulation, in the place of inflections of voice; and to use contortions of features instead of the natural expression of the eyes, and the easy movement of the countenance. It is in vain, that critics inveigh against the bad taste of those, who prefer show, and pantomime, and processions, and dancing, and all that the French call *spectacle:* unless we can hear the sentiments and dialogue, it is useless to write good plays; but all the world loves *spectacle.* Both these tastes should be gratified. Garrick, as I have heard him declare, was always entertained with a pantomime: he told me how many times he had seen Harlequin Fortunatus with delight—the number I forget, however I am sure, that it far exceeded the number of times any mam could hear a good comedy or tragedy. Surely the literary and the visual entertainment of different spectators might be gratified. In the first place, the audience-part of the theatre should be left smaller, and lower, than it was at Drury-lane. Its shape might undoubtedly be improved, by constructing it according to the known laws of acoustics: but this, if rigorously attended to, would contract the space so, as to affect too much the *receipts* of the house.

The area for the stage might be as large as it was formerly; but the scenery should be adjusted so as to contract the stage to reasonable dimensions. To confine the voice, the wings should have leaves, or flaps, hinged to them, so as occasionally to close the space between the wings, leaving sufficient room for exits and entrances. When large objects require admission, these leaves might be turned back, and would then allow the same space as usual between the wings. This would be an additional convenience to the actors, while they stand in waiting to enter on the stage, as it would screen them from the cold. The ceiling of the stage, which at present is made by strips of painted linen hanging perpendicularly, should be made of well varnished iron or copper frames, turning upon centres so as to open at pleasure like venetian window-blinds; and by this means to contract, at will, the opening of the ceiling, and to conduct the voice of the performers towards the audience. The current of air, so as it does not amount to wind, should flow from the stage to the audience. By experiments tried upon sound by sir Thomas Morland and some other members of the Royal Society, it appeared that the propagation of sound was prodigiously obstructed by the assistance or opposition of a slight current of air. We are told by Vitruvius, and Lipsius, that the sound of the actor's voice was increased in a surprising manner by brazen vessels placed under the seats of the audience.

No satisfactory account remains of the manner in which this desirable effect was produced. It would not however be difficult to try experiments on this subject in any one of our theatres when it is vacant.

About forty years ago I happened to go with a friend into a large cockpit at an inn at Towcester. My friend, who was at the opposite side of the pit, appeared to me to speak with a voice uncommonly loud and sonorous.

Upon my inquiring why he spoke in that manner, he said that he had not raised his voice above its ordinary pitch. Upon looking about I perceived a large earthen jar behind me, which proved the cause of this increase of sound: for upon repeated trials the voice of my friend sounded as usual when I stood in any other part of the cockpit, but that in which the vase was placed. To the best of my recollection the jar was about five feet high, and twenty inches in diameter. I remember well, that it rung clearly, but slowly, when struck with the knuckle. By what means, and by what materials, the pulses of sound may be best returned for the purposes we have in view, is a subject for the joint efforts of mathematics and experiment.

Among other expedients pannelling the backs of the boxes with thin elastic plates of brass might be tried.

A saving and advantage would certainly arise in all cases from using iron, or copper, instead of wood; they would not require renewal for many years, and they would be a preservative against fire. The prompter's box might certainly be improved, so as to throw the prompter's voice more distinctly upon the stage, and to prevent its being heard by the audience.

4. *Convenience to performers.* Notwithstanding the reveries of Rousseau, and the declamations of the over-righteous, actors have risen in the estimation of the public. We have seen with rational and sincere pleasure the excellent conduct of many female performers. I consider this reform as highly advantageous to morality, and it becomes a duty in the managers of a theatre, to accommodate the performers with every possible convenience, so that they may enjoy that English word *comfort*, which in all situations of life tends to promote independance and morality.

It is scarcely necessary to add, that pipes to speak through should be laid from the green room to every apartment of the actors.

6. I have left the article of *expense* to the last, because whatever essentially tends to the convenience and gratification of the public will always find sufficient supplies from the liberality of Britain. A small addition to the price of the tickets would amply defray the expense, that would be incurred by any real improvements.

If the united efforts of men of science and men of practice were directed to this object, we might expect to see a theatre superior to any on the continent, adapted both to the purposes of splendid exhibition and of true comedy; where our children might be entertained with the "Forty Thieves," and ourselves with "The Rivals" and the "School for Scandal."

RICHARD LOVELL EDGEWORTH.

To Mr. NICHOLSON.

No. 70.

Description of a very simple and cheap Contrivance for making Port Folios of large Dimensions. By the late JAMES MALTON, *Esquire.**

(With an engraving.)

SIR—As I well know the great inconvenience experienced by artists and collectors of prints and drawings, from the want of portfolios of dimensions capable of inclosing large subjects, and as I also well know that the means used by the Society for the Encouragement of Arts, &c. to promulgate knowledge and useful informa-

* Nicholson, vol. 9, p. 128. From the *Transactions of the Society for the Encouragement of Arts, &c.* for 1803.

tion are earnest as they are extensive, I am induced to lay before that body a port-folio of my construction, which I persuade myself possesses every advantage that can be wished.

The difficulty, or rather the impossibility of obtaining cases or port-folios, as large as are sometimes requisite, has given rise to many expensive contrivances, to the same end; or large prints, &c. must be kept in rolls, to their almost certain destruction, by frequency of rolling; or at least they are thus exposed to the danger of being crushed by accident. Milled pasteboards, of which port-folios are made, are not manufactured above a certain moderate size: to exceed that size in a port-folio, is an undertaking of no inconsiderable trouble, in pasting, glueing, and pressing them together. On inquiring of Mr. Newman, of Soho-square, (a manufacturer of these articles,) how he managed to make port-folios above the ordinary dimensions, he informed me, it was an undertaking of trouble, and related his having made one for a gentleman, by attaching sixteen of the largest milled boards together; that the materials alone cost five guineas; and that its weight was greater than one man could lift.

My method of construction obviates all disadvantages—weight, expense, and trouble; and port folios of any dimensions may very readily be manufactured by the simple application of two straining-frames, covered on both sides with canvas, and papered; and connected, as all port-folios are, by leather at the back, or with wooden backs, the sides being connected by hinges. Thus a port-folio may be made capable of holding the largest cartoons, maps, and prints; and possessing another great advantage, besides that of not bellying or swagging, when laid against a wall, as those constructed of pasteboard

do, to their own destruction, and material injury of the things they contain.

A frame of four feet by three will be strong enough, if made of deal. The stiles are four inches wide by half an inch thick; and they have a middle upright stile of the same width, with angle pieces at the corners, as is shown in the engraving, fig. 1, plate 11. A frame of much greater dimensions may require two middle upright stiles; and, if very large, a middle longitudinal stile, as is shown in the engraving, fig. 2.

If the frames are made of mahogany, they need not exceed three sixteenths of an inch in thickness; but, of whatever wood they are made, it must be well seasoned, or they will warp. A padlock may be applied to such cases, for the protection of their contents.

On this construction I have made two port-folios, one of which I have had in use these ten years. A handsome one, of tolerably large dimensions, I have sent with this paper, for the inspection of the Society. The outer stiles of it are of mahogany, which, beaded, forms the out edge in a neat manner. Its simple formation, its lightness, and its firm flatness, must be obvious to every one; and I am of opinion the Society will obtain the thanks of all collectors and artists (if they think it worthy of insertion in the volume of their Transactions) by making this simple matter publicly known. For my own part, I shall be highly gratified in having contributed to the comfort of artists and collectors, in preserving their valuable researches. I am, &c.

JAMES MALTON.

Norton-street, June 25, 1802.

Reference to the Engraving, Plate 11.

Fig. 1. One of the sides of a frame for a port-folio, the dimensions four feet by three: it may be made of deal or

fir wood. The stiles, four inches wide by half an inch thick; the middle upright stile to be of the same width. It should have angle pieces within the corners, to keep them firm.

Fig. 2. Shows a side of another frame, where much larger dimensions are required; it should then have two upright stiles, and a middle longitudinal stile, all within the frame, and angle pieces at the corners. If it is made of mahogany, instead of deal, the stiles may be reduced nearly one-fourth in breadth and thickness; the wood, in either case, should be well seasoned, that it may not be liable to warp.

No. 71.

Account of an improved Sheep-Fold, contrived and constructed by THOMAS PLOWMAN, *Esquire.**

(With an engraving.)

THE model of Mr. Plowman's Sheepfold was forwarded to the Secretary of the Society of Arts last year with a letter describing its properties and construction. It is made on an improved and very simple principle, combining many advantages over the old and expensive method of folding by hurdles; and as the whole fold can be removed with ease at all times, it is found peculiarly useful in feeding off turnips on the land in frosty weather, when hurdles cannot be used; and, as the saving of labour in agriculture is a leading object, he has no doubt of seeing it, in a very few years, generally adopted.

The expense, in the first instance, will exceed that of hurdles, for the same given quantity of sheep; but having

* Nicholson, vol. 12, p. 192. From the *Transactions of the Society for the Encouragement of Arts, &c.*—The Society awarded the gold medal to him for this useful improvement.

had one in use nearly three years, he is satisfied the saving will be very considerable: for, before he adopted this method of folding, he lost from thirty to forty nights folding in the year, owing to the land being hard in dry seasons, such as the two last; which renders folding almost impracticable, as they never can be set without great labour and destruction of hurdles. He is also clearly of opinion, that the stock of sheep will be greatly increased when this method of folding becomes more known; and that it will enable many small farmers to keep from fifty to one hundred sheep, who now are deterred from it, on account of the small quantity of feed they have, not answering to keep a man for that purpose only; but by this plan, they may keep a boy at three shillings or three shillings and sixpence per week, who can attend on one or two hundred sheep, and move the fold himself without any assistance. In heavy gales of wind it frequently happens that hurdles are blown down, and the sheep, of course, being at liberty to range over the crops, do incalculable mischief; which cannot happen with this fold.

In some counties in England, where hogs are folded, great difficulties are experienced for want of stowage, for them to feed off winter tares, &c. as they root up every stake or hurdle; but from having tried the experiment, the inventor is certain his fold will keep them in, and defies their attempts to displace it.

From this drawing, which corresponds with the model, and from the description, it is seen that an astonishing quantity of time is saved; for one man can remove a fold to contain three hundred sheep with ease in five minutes, which, by the old method, frequently takes some hours to accomplish.

Certificates of gentlemen, who use these new folds,

were sent to the society, among whom is that of his grace the duke of Bedford.

When the fold is wanted to be used on very hilly ground, it is best to begin at the top, and work it down to the bottom, for the ease of removing it, and then draw it up again with a horse. This, however, the inventor has never had occasion to do; for the land in his county is ploughed in a contrary direction, and the fold is worked in the same course as the ridges. By this mean, the inconvenience is avoided of crossing the furrows, and they are also a guide to keep the fold in a straight direction.

With respect to the sheep getting under, he does not recollect that circumstance to have ever happened, nor does he conceive that any land, which is cultivated can be so uneven as to admit of it.

Description of the Sheepfold.

PLATE 11, fig. 3. Shows one division or part of this fence twenty-one feet long, and three feet eleven inches high, composed of the following parts:

A. A top rail three inches deep and two inches thick. B. The upper bar, three inches deep, and three-quarters inch thick. CC, The two lower bars, four inches by three-quarters of an inch, which, with the upper bar, are morticed through the uprights. DDDD, Which uprights are oak, three inches by two inches. E, the lower bar, three inches by three. F. An upright bar, with the horizontal bars halved into it. GG, two oak uprights, three by two inches.

Fig. 4. Shows the oak uprights GG. H, The axletree, three inches by three, and three feet between the wheels. I, An oak knee, which connects the uprights GG with the axletree, by means of two screws and nuts.

Fig. 5. A plan, in which the axle H is shown with two arms KK at right angles to H, which are made to act as pivots to the wheels, when intended to be moved in a direction at right angles to the bars.

Fig. 6. Is a view of the same parts described in fig. 5. The wheels marked W, in all the figures, are of cast iron, and cost three shillings and sixpence each.

NO. 72.

Account of an Improvement in Tram Plates for Carriages on Rail Roads. By Mr. CHARLES LE CAAN.*

(With an engraving.)

SIR—I have forwardad to the Society of Arts, &c. a specimen of my new method of laying rails, or tram-plates, on such a plan as has met the entire approbation of those who have seen it, and are acquainted with the principle on which such roads should be formed. Rail roads are daily increasing, from the great advantage they afford to manufactories connected with mines and minerals, and particularly to collieries. They also promote agriculture, by occasioning lime to be procured from places almost inaccessible by any other means, or whence it could be otherwise brought on moderate terms.

I flatter myself, that every improvement on this system will be of national importance. The honour I received last year from the Society of Arts, &c. has stimulated me to submit the present subject to their consideration.

I have also sent a drawing of my method of laying the tram-plates, with an estimate of the saving that will arise

* Nicholson, vol. 22, p. 339. From the *Transactions of the Society for the Encouragement of Arts, &c.* vol. 25, p. 87.—Twenty guineas were voted to Mr. Le Caan for this improvement.

to the public, by adopting the said method, with necessary remarks on the principle on which it is founded. The leading rail or tram-plate has neither tenon nor mortice over the plug. The stop-plate terminates the specimen, which stop-plate should go in with some degree of tightness when laid for actual use, but in the present case that force is not necessary, as the wooden blocks, by a carriage of upwards of two hundred miles, may in some small degree be misplaced. I hope any impediment of that nature will be rectified or allowed for. I wish it to be understood, that a stop-rail is intended to be placed at every thirty yards, at which distance any repairs may be made within ten minutes, which by the present mode frequently occupies more than twice that time, exclusive of disturbing in some measure the line of road. By my method, the plates have a certain degree of play, which is absolutely necessary to avoid that breakage, which too frequently takes place when they are fixed with nails and plugs.

The plates which I send have been fixed in stone blocks, and are nearly as rough as when taken from the sand. If I am favoured with any mark of the society's approbation, I shall hold myself bound to transmit such farther communications on this subject as may be required by them, or any person desirous of adopting my plan. I am, &c.

CHARLES LE CAAN.

Llanelly, Carmarthenshire, May 12, 1806.

SIR—I have considered the improvement made by you in the specimen exhibited of a new design of a tram-plate, and am of opinion, that much advantage may be derived to tram roads by the adoption of your plan, in preventing the temptation of stealing the wrought iron nails, with

which the plates are usually fastened, and by facilitating the operation of laying down new tram roads, and repairing of old ones. I am, &c.

J. VANCOUVER.

To Mr. LE CAAN.

Llangennech Park, April 2, 1806.

SIR—Several tram-plates on your new method of fixing without either nail or plug have been cast under my immediate inspection, at Stradey furnace. The same may be made with as much ease as any others now in use, and I conceive they will obviate the many impediments that arise from the irregularity of driving the nails. I have no doubt from my observation of yours, but that they will answer extremely well, and prove less expensive. I am, &c.

J. LEWIS.

To Mr. LE CAAN.

Stradey Furnace, April 18, 1806.

CERTIFICATES were also received from Mr. R. Jones of Swansea, agent to general Ward's colliery; from Mr. James Barnes, who formed the Mynther and Carmarthenshire rail road; and Mr. Edward Martin, of Morristen, an eminent colliery, surveyor and planner of rail roads, all testifying the advantage of Mr. Le Caan's invention.

Reference to the Engraving. Plate 11, *Fig.* 7, 8, 9, 10.

THE tram-plates, fig. 7 and 8, are fastened by means of a tenon and mortice AB, each having a correspondent bevel, just sufficient to keep the end from rising up, so that the head of one plate confines the end of the other:

by this means, the workmen are obliged to form their road in right lines, and maintain perfect levels, as the mortice and tenon confines them to the required exactness necessary to make a perfect road: curves or any given segment may be formed with the same nicety, by having two bevel rails or plates made for such purposes.

Fig. 8, A side view or longitudinal section of the two plates placed on their stone blocks or sleepers CD, shows two plugs in dotted lines, one bevel, the other perpendicular, cast in the stop-rail or plate, which is so called as it prevents the others from moving, and when taken up releases all those between the stop-plates; twenty-five yards of rail roads made with these plates, may be taken up and replaced within ten minutes. The plugs in dotted lines are shown in their proper positions within the sleepers EFG.

The usual length of a tram-plate is three feet, the flanch or outside edge H, about one inch and half high, the sole or bed I, from three inches and a half to four inches broad, and three fourths of an inch thick; but these dimensions may be varied according to circumstances. The most approved weight has been fourteen pounds to the foot, or forty-two pounds to the plate, the ends from which the plugs project, and to which the tenons and mortices fasten, should be one fourth of an inch thicker than the other part of the plate.

Fig. 9. AB show the under part of the tenon and mortice, and the form of one of the sloping or bevel plugs.

The diameter of the plug near the shoulder is one inch and three quarters, reducing to one inch, its length two inches and a half, forming an angle of eight degrees, the plate from which it projects is counter sunk, so that the shoulder of the plug may not receive any sharp pressure or prevent the plate from having a perfect bearing.

There is a small groove in the whole length of the exterior of each plug, to admit a wire to pass to its extremity, to draw the plug out if broken by any accident, also to admit the expansion of water, in case of severe frost.

The blocks or sleepers, EFG, on which the tram-plates are placed, should by no means be less than one hundred and twenty pounds each in weight, but should be heavier on some kinds of ground: the depth of the hole for the plug should be three inches, and worked according to the inclination of the plug, for which purpose the stone-mason should have a standard cast-iron guage; there should be projections, K, cast with the flanch or outside edge of the tram-plate, as shown at fig. 7, to make the plates lie firm on their sleepers.

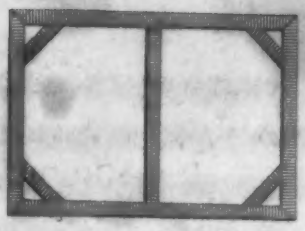
Fig. 10, is a section of one of the ends of a tram-plate, in which H shows the flanch or upright edge, I the flat part or sole on which the wheels of the waggons run, D one of the plugs, K the projection behind the flanch to make the plate lie firm on the blocks.

General Observations.

The advantages of laying plates on the above principle are obvious; the blocks being put in their places never sink below their intended level, the act of driving either nail or plug, (which requires a considerable degree of force, and too frequently destroys the level of the road,) being here unnecessary. In the common mode of making rail-roads, from the irregularity of nails, particularly in forming their heads, few can be driven exactly even with the plate, and they are perpetually obstructing the passage of the waggon; the workmen frequently not proportioning their holes and plugs to the hole in the block also occasions considerable breakage; the exertion necessary to fix a rail or plate completely is great, and

Malton's Portfolios.

Fig. 1



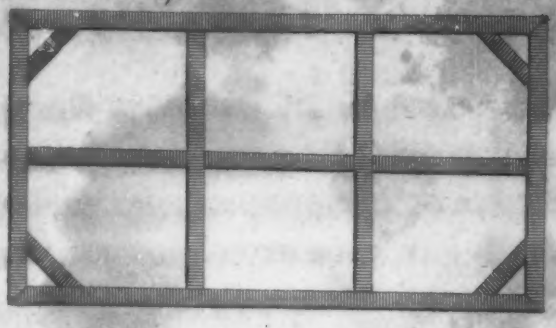


Fig. 2

Plowman's improved Sheep-fold.

Fig. 3.

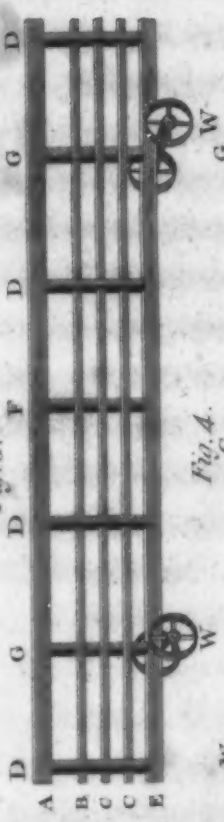


Fig. 6.

Fig. 4.

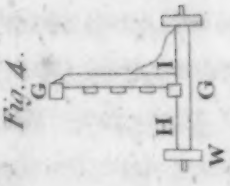


Fig. 5

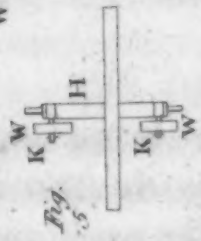
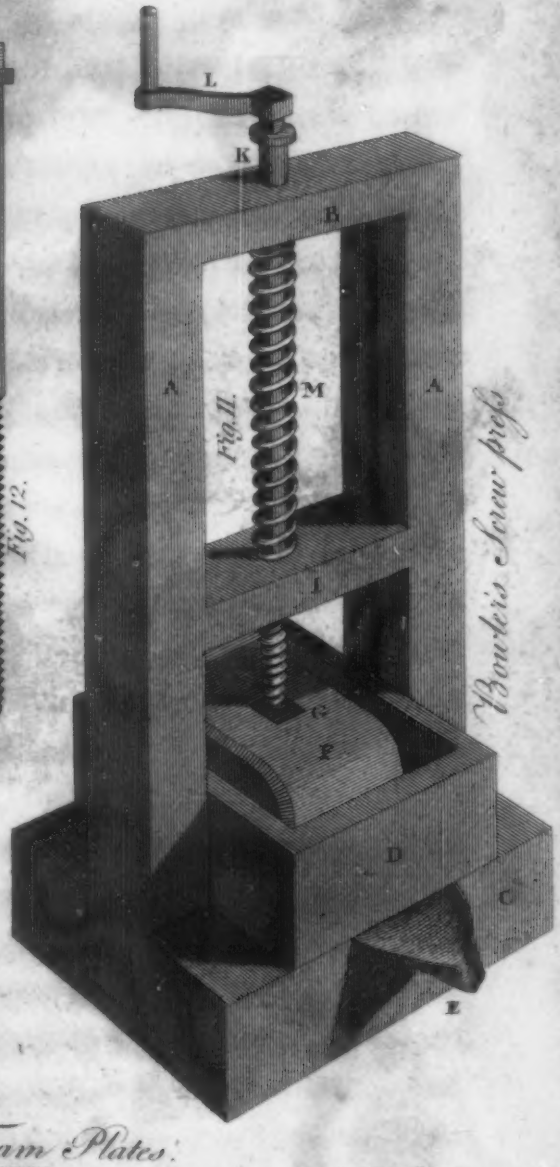


Fig. 12.

Boutet's Screw-press

Fig. 11.



Le Caan's Tram Plates.

Fig. 7.

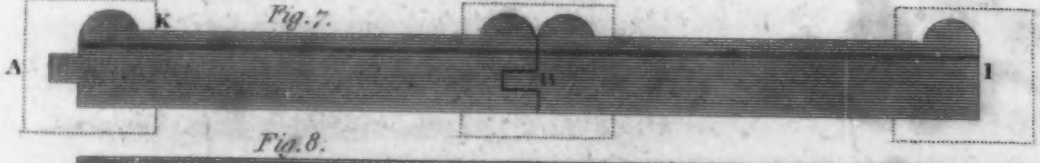


Fig. 8.

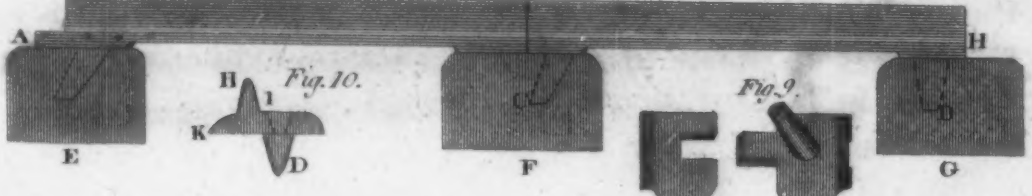


Fig. 10.

Fig. 9.

Emporium of Arts & Sciences — Vol. 2 pl. 11.

Tiebout Sc

numbers of plates, particularly when the iron is short or brittle, are broken near the mortices by missing the stroke of the hammer, which must be used with great force.

Advantage gained in laying my Tram-Plates in Comparison with other Modes.

	L.	*s.*	*d.*
Nails used in a mile, 3520 of 3 in the pound, at 4*d.* per lb.	19	11	0
Nails lost or defective, computed at per mile	1	0	0
Plugs with their loss	6	5	0
By breakage of rails, average from experience	7	10	0
Lessened by labour in block laying, calculated at only two pence per yard . .	14	13	4
By breakage of blocks	1	0	0
	*L*49	19	4

This calculation does not take in annual loss of nails, and breakage of blocks, which is considerable.

No. 73.

Description of a Screw Press with an expanding Power. *By Mr.* William Bowler.

(With an engraving.)

SIR—The screw and spring-press which I have the honour to present to the inspection and for the approbation of the Society for the Encouragement of Arts, &c. will, I trust, be found in a superior degree adapted to

*. Tilloch, vol. 21, p. 249. From the *Transactions of the Society for the Encouragement of Arts, &c.* vol. xxi.—A bounty of ten guineas was voted to the author by the Society.

the purpose of pressing bodies in general, but more particularly cheeses, apples, linen, &c. because such things require a firm and unrelaxing pressure:—and this is a peculiar advantage incident to this machine; for after it is set, or the spring screwed well up, it will be found, that as the *article* pressed shrinks from it, so the spring, owing to its peculiar expanding power, gradually follows the object of its pressure, and hence continues to maintain an uniform and equal action on the body on which it is placed. This, in cheese-making, will be found peculiarly advantageous; for it is from this very cause of want of sufficient pressing that cheeses are frequently so very bad. Were the curd entirely separated from the impure and contaminating mixture of the whey, which must be effected by the regular action of this machine, we should always have the cheese firm and wholesome; and, I have not a doubt, the press will be found equally useful in all other cases, and answer every purpose, even beyond expectation, to which it is adapted. I am, &c.

WILLIAM BOWLER.

To CHARLES TAYLOR, Esquire.

Reference to the Engraving. Plate 11, *Fig.* 11.

AA, the two upright sides, or frames of the press.

B, the cross piece which connects them at the top, having a hole in its centre, for the screw.

C, a strong block of wood, into which the two sides of the press are firmly morticed.

D, the box, in which the article to be pressed is placed. This box has a number of holes in its bottom, through which the liquid matter when pressed out passes, and is discharged from the mouth of the spout E, a small hollow being left under the box, to allow its passage to the spout. A loose wooden cover fits into the box D, and upon it is fastened a stout piece of timber F, and an iron

plate G, for the point of the screw of the press to act upon.

H, the male screw of the press, working in a female screw in the centre of the strong cross piece I, which cross piece slides up and down in grooves within the two sides of the frame, one of which grooves is shown in the plate, and about half the length of the side piece.

K, the upper part of the iron screw, on which the handle L, which moves it, is placed upon a square. The iron of the screw is only wormed about half its length.

M, a strong spiral spring, made of iron wire, or iron rod, placed in the centre of the cross pieces B and I; this spring presses downwards against the cross piece I, forcing it as low down as the side grooves will permit. The male screw H lies within the circle of this spiral; and, when the screw is turned, passes through the female screw below it, and acts upon the iron plate G, under which the matter to be pressed is placed, by continuing to turn the screw. As it meets with resistance at the point G, it gradually forces back the cross piece I, by means of the female screw within it, and compresses the spiral into a small space, between the two cross pieces, in which state it remains, till the article which is pressed in the box begins to give out a part of its contents. The spiral spring M, compressed as above mentioned, then begins to expand, and exerts a continued re-action upon the cross piece I, on the male screw H, the iron plate of which covers the article under pressure.

Fig. 12, is the male screw, separated from the other parts, to show how far the thread or worm extends upon it.

No. 74.

Method of Securing the Beams of Ships, without wooden Knees made of one Piece. By Mr. George Williams.*

(With an engraving.)

I SUBMIT to you, for the inspection of the Society, the following particulars of my invention for the better securing of the beams of ships of war, East and West India ships, and all others where strength, dispatch, room, and cheapness are required. In this method less iron in weight, and fewer bolts are necessary, than in the iron knees before in use; there is also less strain upon the bolts, as the block underneath is morticed both into the beam and side of the ship, as well as bolted.

Upon this plan the work is all done under the hand, which is executed much quicker than in the former plan, where the work is all done over hand, and where great nicety is requisite in making the bolt-holes which pass through both the iron stays. In my method much more room is also gained between decks for stowage and working the guns, and even a porthole may be made under the beam itself.

I calculate the saving in a 74-gun ship or East Indiaman to be as follows, viz.

	Ton.	*Cwt.*	*qrs.*	*lbs.*		*s.*	*d.*		*L.*	*s.*	*d.*
Copper bolts,	2	1	3	9	at	1	4	*per lb.*	305	8	0
Iron,		2	12			56		*per cwt.*	145	12	0
Three men and one boy's time for a month									45	17	6
Timber									50	0	0
									*L*546	17	6

* Nicholson, vol. 26, p. 187. From the *Transactions of the Society for the Encouragement of Arts, &c.* vol. 27, p. 142.—The silver medal was voted to Mr. Williams for this invention.

Williams method of connecting the Beams of Ships with their Sides.

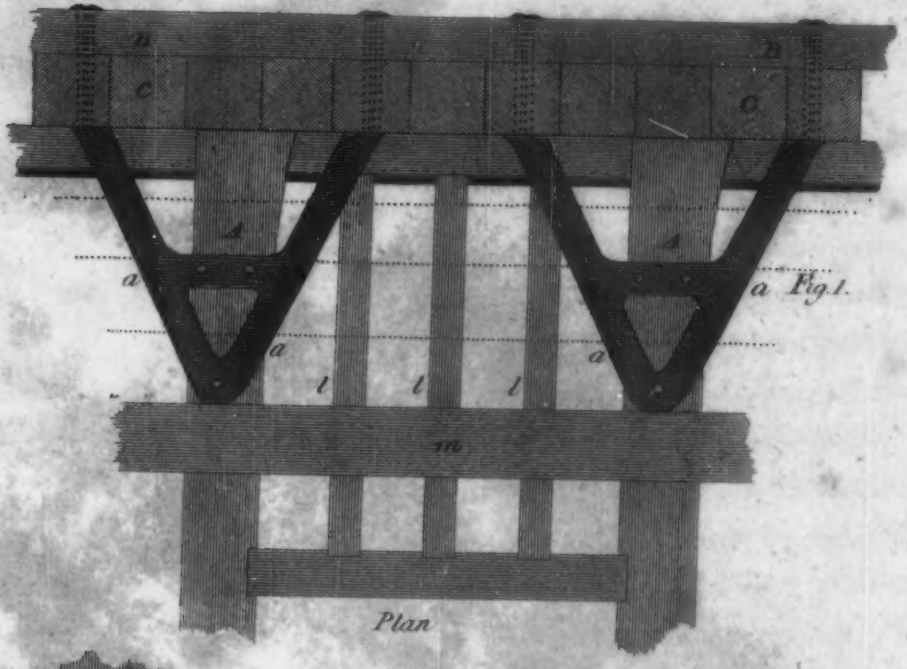


Fig. 1.

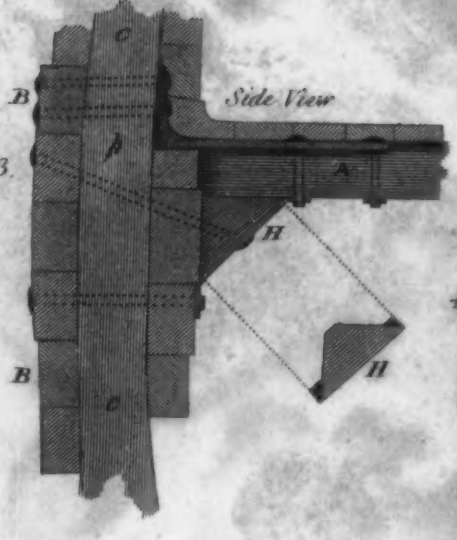


Fig. 3.

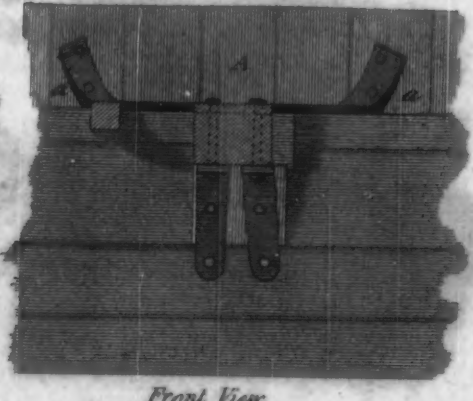


Fig. 2.

Varlys improved Linch pins for Axletrees.

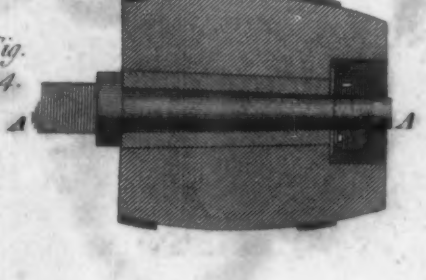


Fig. 4.

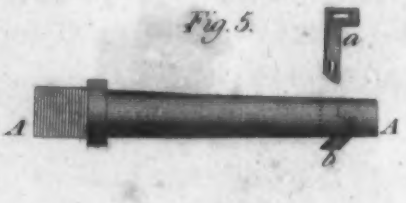


Fig. 5.

Emporium of Arts & Sciences Vol. 2. pl. 12.

Tiebout. S

The models I have sent will, I trust, clearly explain to the Committee every circumstance, which will be thought necessary. I am, &c.

GEORGE WILLIAMS.

Explanation of the Engraving. Plate 12, Fig. 1, 2, and 3.

FIG. 1 is a horizontal plan of a portion of a ship's side; the planks of the deck being removed, to show the ends of two of the beams AA, which extend across the vessel. BB is the outside planking of the ship; CC the sections of the timbers or ribs; and to these the beams AA are fastened by beaten iron triangular braces *aa*, similar in form to the Roman capital letter A. These are let into the beams, and attached there at the angle by three bolts going through them. Fig. 2 is a front view of only one beam, where the spectator is supposed to be looking towards the ship's side; and fig. 3 is part of a cross section of the vessel's side; the same letters are used as in the other figures. By inspecting these, it will be seen, that the ends of the brace *aa* are turned up and bolted to the timbers of the ship's side by two bolts passing through each end, and through the timbers and the outside planks; by which means the beams are secured from lateral motion: and to brace them in a vertical direction the wooden block H, fig. 3, is fitted in beneath them, and two iron straps bolted on them; one end of each of these straps is attached to the deck beams by the same bolts as the upper brace *aa*; the other ends are bolted against the inside planking, and an oblique bolt *h*, fig. 3, passes through the middle of each strap and the ship's side; *lll*, fig. 1, are the small intermediate beams, answering to the joists of a floor, to which the planks of the deck are spiked down; *m*, fig. 1, represents one of the planks, and the dotted lines show the joints of the others. In fig. 3, these planks

are shown, and the other beams to make all sound and firm, which were removed in the other figure to show the braces.

No. 75.

Method to prevent the Accidents which frequently happen from the Linchpins of Carriages breaking or coming out. By Mr. J. Varty.*

(With an engraving.)

SIR—Herewith you will receive a model of an axle-tree for public machines, intended to prevent the wheel from coming off, if the linchpin should break, and thereby prevent many dangerous consequences. When the idea first suggested itself to me, I put it in practice in a stage coach, which has since run from Liverpool to Litchfield, a distance of eighty-four miles, six days per week, for the last six months. During that time several instances have occurred in which the linchpins have broke or come out, but owing to this contrivance no accident has happened therefrom. We almost daily hear of stage coaches being upset, which more frequently arises from linchpins breaking than from any other cause.

In offering this model to the Society of Arts, &c. for their inspection, I anticipate the pleasure of their sanction, as I can furnish satisfactory vouchers of its proved utility. I am, &c.

J. Varty.

Description of the Engraving. Plate 12, *Fig.* 4, *and* 5.

Fig. 4 is a section of the nave of a carriage wheel, with the axle-tree AA in it; and fig. 5 is a separate view

* Nicholson, vol. 26, p. 189. From the *Transactions of the Society for the Encouragement of Arts, &c.* vol. 27, p. 145.—For this invention the silver medal was voted to Mr. Varty.

of the axletree. *a*, fig. 5, is the linchpin detached; it is put through an oblong hole in the axle as usual, but there is likewise an additional linchpin *b*, to make it complete, which is fixed in a recess cut for it in the axle, and turns on a pin (as is shown in the figure) into the hole left by removing the linchpin *a*, when the wheel is to be taken off; but if the linchpin *a* should accidentally get out, this additional pin *b* would effectually keep the wheel on, as its hanging position does not at all tend to shut the pin up into the axle, but the contrary. The common linchpin *a* is put in downwards, and its weight may also tend to keep it in, and is secured in the usual way by a strap, the holes for which may be seen in the figures. The whole, when in its place, is shown at fig. 4.

No. 76.

On the Construction of Theatres, so as to render them secure against Fire. By Mr. B. Cook.

SIR—In some former letters you did me the favour to insert in your Journal, I have recommended the use of iron in the place of wood; in my last on that subject I pointed out its use and advantages in substituting it for wood in buildings, but more particularly in adopting it for staircases, as promising a certain escape in case of fire. What I would direct the attention to in this is, the great advantage of employing it almost entirely in the erection of public buildings, especially theatres; and although I am not an admirer and encourager of theatric representations, but, on the contrary, think they are injurious to a state, as contaminating the morals and habits of a people, and consider them as the very seat and emporium of vice and immorality, yet as they are permitted, it is a

* Nicholson, vol. 25, p. 301.

desirable thing, to have them erected in such a way, that, for safety's sake, the frequenters may not be in danger from any accident or other cause. We have seen the two national theatres destroyed entirely, and that with a rapidity that no human exertion could put a stop to. Their destruction arose no doubt from an unpardonable neglect, or a worse cause: one has risen like a phœnix from its ashes, more beautiful than before, but is it not risen with all the dangers of destruction in itself? It ought to have risen immortal; it ought, as a national establishment, to have been composed of such materials, as would mock a second dreadful devastation. A fire once commenced, would it not, in this new theatre, communicate to all its parts? Would it not put at defiance the power of man to suppress it, and in a few hours would it not again be a heap of ruins? Drury Lane is still in this situation; and as it is in contemplation to raise it to its former splendour, and as another theatre is about to be erected also, I do hope, before they are erected, that the proprietors will carefully consider how absolutely necessary it is to compose them of such materials, as will endure for ages, and that cannot be again consumed with fire. The destruction of Covent Garden was accompanied with the loss of so many lives, that no care or expense can be too much to guard against so dreadful an accident. I mention not the loss the proprietors sustained, I take not that into the scale, for what is the loss of property, when compared with life? The nation ought to superintend the erection of its public buildings, especially those buildings set apart for amusement. The lives of his majesty's subjects ought to be as carefully provided for by the legislature, in their meetings together for amusement, as it provides for them from their enemies from without. I always have considered all such places as extremely dangerous, not that I suppose that a fire

could begin and communicate itself round the house with such rapidity as to endanger the lives of the auditors; but what is as bad, or worse, on the first appearance or cry of fire, instantly would the audience rush from their places to the doors, and hundreds of lives would perhaps be lost; for the very idea of a fire deprives a man of that command over his reason, especially if he conceives the danger imminent, that at the first scream of fire, all would press to escape, so that numbers would be suffocated, crushed, or trodden to death. The second view I would take is, that on such immense piles of building being in a blaze, if the wind should be high, vast danger might be the consequence; and in the attempt to extinguish fires of this sort, we have a recent instance in Covent Garden, how dangerous is the employment of the firemen and assistants. I will suppose, that a theatre was constructed of iron instead of wood. If the scenery during the midst of the performance was to take fire, and the whole in a blaze, the spectators might rest quiet, it could not extend to reach them; and I do think, that, although the whole house resounded with the cry of fire, the idea would fix itself on the mind so strongly, that they were sitting on iron, that the alarm would not so much affect them, if it did at all, as to produce any mischievous consequences. The very thought of the theatre being incombustible would draw to it many persons, who, from a fear of accident, might now keep away. The security it promises to the proprietors not only from real danger, but from the alarm of danger, would, I should suppose, (especially if it can be made appear, that it would be erected as cheap, or nearly so, as of wood) induce them to adopt this plan.

I will give a brief description of the mode, and although imperfect, yet all I wish is to strike the mind with the idea, and induce the proprietors to give it due considera-

tion. I will begin with the stage—all the upright and cross supporters should be iron, cast light, fitted, and screwed or pinned together, and to make it fire proof, projecting edges might be cast on the bottom of each spar, so that when laid down to lay the floor upon, tiles or quarries made thin and light on purpose might be laid between the spars, forming a solid fire proof bottom. Then the boards for the stage might be laid down and screwed to the spars; the same principle acted upon through all the rooms, and all the doors neatly made of iron, with pannels to fall into the mouldings neatly screwed in, which when painted would be as handsome as mahogany. The stairs and staircases all cast and fitted together in the way recommended in your Journal, No. 107, would be much more beautiful than it is possible to make wood, without going to a very great expense, and then not half so durable. They would be much cheaper than stone also. In fact, I would introduce little or no wood at all, except the floors, and these I would lay down fire proof.—It would then be impossible for fire to be communicated to the different parts of the house, was the vilest incendiary to gain admission under cover of the night, and fire the boards of the stage and scenery, there being none, or but little admission of air from below, owing to the fire proof bottom, it could make its way but very slowly, and then only the boards and scenery could be burnt. All communication being cut off with the adjoining rooms by the iron doors, it could not consume their contents, and the supporters of the floorings, being iron, could not conduct the flame. The front of the stage and orchestra should be iron; the orchestra in particular would be extremely handsome, cast with beautiful festoons of flowers or trophies, and painted in character. The flooring of the pit laid on arches could not be in danger, and the seats of the pit also should be

iron, the supporters of the seats cast light, and the seats made in pannels from three to six feet, neatly cast to fall into the mouldings with round edges, so that when the supporters were fixed, the framing laid down, and screwed firm, then the pannels should be let into the mouldings, and fastened with screws also. The seats made in this way would be quite as neat, and all the objection I see is, that iron would be colder than wood; but when they are covered, that objection in part would vanish—at all events, the supporters of the seats might be iron, if the seats were wood. The framing for the boxes might all be of iron, and the seats iron also, for they are stuffed, therefore iron could be no objection. Then the partitions of the boxes might be very neatly managed and light, being all cast in open work, and the fronts of the boxes might also be cast in scrolls, Gothic, or in trophies, in fact, in any way, figure, or shape, fancy might invent, more tastefully, more light and elegant, than it is possible to do it in any other way. Then, if it was wished, the fronts of the boxes might be rendered warm, if the open work was objected to as cold, by lining them inside with cloth or velvet, which would form a very handsome ground, on which the scroll or fancy work of the boxes would be seen to great advantage; the back of the boxes and doors I would propose of iron laid in pannels, and tastefully painted or lined—a person would not be able to discover, whether they were made with wood or iron inside, if well managed in the padding. The lobbies, the small staircases, the railing, the supporters and framing of all kinds should be iron, and all the floors should be laid on fire proof floorings. The grand staircase might be made to have a beautiful effect, if a man of fancy and genius was to design it; and the whole of the grand entrance might be such, as would strike the beholder with amazement at its novelty, and the mind at the

beauty and delicacy of its composition, as in iron the finest specimens of antiquity could be introduced. The supports of the galleries should be iron. The gallery floor laid down fire proof, and the seats, if not iron, should be on iron supporters—the gallery stairs and staircase all iron, and the roof should have no wood at all in it, but be composed of hollow or solid iron, cast light, and if each piece was graduated from bottom to top, would still make it more light, and yet be equally as strong. A roof of this description well secured together with screws and bolts, &c. would not be considerably heavier than wood, as the iron would possess strength equal to wood, at less than half the thickness.

Now it would be well to compare the advantages iron promises above wood, before it is adopted; and in looking at its advantages, all its possible disadvantages should be coupled with them, in order to see it in its true point of view. One objection might be urged, that it would be difficult to erect a theatre or great public building on this plan. But I say there would be no difficulty in procuring men competent to undertake the erection of them, and who are able to plan, get made, and put together all, its several parts; and in those parts where there was a field open for genius and taste to show itself, in the entrances, boxes, and other conspicuous parts of the house, the most beautiful and unique ornaments might be made, and finely cast in iron, and afterwards touched up with the tool, and painted to imitate whatever fancy might dictate. There would be, especially in a theatre, the greatest scope for genius; thus might be constructed the most elegant one in the world; and one that no accident, no misfortune, no incendiary could destroy—that would brave the utmost efforts of time to destroy it—that would endure for ages. Another disadvantage might be supposed, and that is the additional expense in the erection. This might be something more, especially if beauty was

suffered to lead, and genius permitted to exercise itself in the ornamental part; but suppose it was to cost ten thousand pounds more, what is it, in a public national building? especially when you are certain in constructing it in this way, you are constructing a work that will endure for ages. If you use wood, how can you assure yourselves, but by some unforeseen accident it may meet with the fate of the other theatres? Money must not be put in the scale as a competent balance against security. After considering the subject, and examining the way Covent Garden is built and fitted up, I am more and more convinced in my mind, that iron might be substituted for all the timbers, and for fitting up a theatre complete in the way I have before hinted, as cheap, or nearly so, as though it was done with wood. It is then self evident, it would be more durable, perfectly safe from fire, and much more elegant, if raised under the auspices of a man of genius and good taste. I am, &c.

B. Cook.

Caroline Street, February 20, 1810.

Remarks.

That the construction of theatres is a matter of public concern has already been very justly observed by Mr. Edgeworth, in his paper on this subject,* where too the use of iron and incombustible materials is strongly inculcated. Sir George Cayley likewise, in his paper,† recommends the use of iron, but not to the same extent as Mr. Cook; though certainly the more of it can be employed the better. There is one thing however of which Mr. Cook does not seem to be aware, and that is the necessity for trap doors and

* See this volume of the Emporium, p. 353.

† See page 350 of the Emporium.

openings in the floor that forms the stage: but this is of little consequence, for they might be contrived in a floor of iron, as well as in a floor of wood. To obviate the objection of increased expense, Mr. Cook brings against it the increase of duration, with the probability of larger audiences. But if we likewise take into consideration the saving of insurance, it would probably be found on calculation, that the use of iron would be by much the most economical. This saving, which does not appear to have been adverted to, probably from its amount not being generally known, will be considered as of no small importance, when it is understood, that the offices were paid forty shillings for every hundred pounds insured, previous to the burning down of Drury Lane theatre; and that, since this event, they will not insure at a less premium than four guineas per cent. Now the proprietors of the theatre lately erected at Covent Garden state the expense of erecting it at one hundred and fifty thousand pounds; the insurance of which against fire would amount to no less than six thousand three hundred pounds a year. If, as I suppose, scenery and dresses be not included in this estimate, the insurance would be still more to cover the whole. And to insure only one third of this, or fifty thousand pounds, as on the old theatre, the premium would be two thousand one hundred pounds a year. Would not the saving of such a sum annually more than repay the additional expenditure for rendering the building proof against fire by the general use of iron? to say nothing of other advantages.—NICHOLSON.

No. 77.

Tools to answer the Purpose of Files and other Instruments, for various Uses, made of Stone-ware. By G. Cumberland, *Esquire.*

SIR—To some men, but not to you, will it appear a trifle, because very obvious on reflection, to have applied so soft a substance as clay to the purpose of lograting the hardest bodies; neither should I perhaps have ever thought of such an application in the form I now use it, had I not found, in shaping of some substances, that the wear of my steel files was rather expensive.

It then first occurred to me, in ranging in thought after a remedy, that, as our stone-ware is so hard as to blunt our files, files might be as well made of our stone ware. This was about two years ago, and the first use I made of this suggestion was, to fold up in muslin, cambrick, and Irish linen, separate pieces of wet clay, forcing them by the pressure of the hand into the interstices of the threads, so as on divesting them of the covering to receive a correct mould. These I had well baked, and immediately found I had procured an intire new species of file, capable even of destroying steel; and very useful indeed in cutting glass, polishing, and rasping wood, ivory, and all sorts of metals.

The ease with which I had accomplished my purpose, as is too often the case, made me content myself with the use of my own discovery, or at most giving away a few specimens as files for ladies nails of peculiar delicacy: but having since reflected, that in glass grinding (the stones for which come from the North, and are very expensive) in flatting metallic mirrors, laying mezzotinto

* Nicholson, vol. 25, p. 257.

grounds, and a number of operations that require unexpensive friction, these stone-ware graters, if I may so call them, as not being of the exact shape of files, may ultimately become very useful. I take a pleasure in furnishing you with a description of my method of applying this substance, accompanied with a specimen or two of a portable size, that you may the better be able to judge of their value to the arts, which to me the more I reflect on them seem the more important; as in all operations of grinding a great deal of manual labour must first be bestowed on the tool, whereas here we may mould ours in an instant, if we use a press, as in pipe making, and the expense is infinitely inferior to that incurred in constructing even the cheapest file or lograter. I am, &c.

G. CUMBERLAND.

To Mr. NICHOLSON.

Bristol, February 10, 1809.

P. S. I have not yet tried it, not having the means just now at hand, but if a good parabolic reflector were to be impressed with a mass of stone-ware clay covered with muslin, so as to make several casts of different degrees of fineness, we might this way acquire tools, that would greatly lessen the expense of the operation of grinding; but much would depend on care in baking. Our stone ware warps but little ever.

ANNOTATION.

THIS ingenious invention promises to be of considerable use in the arts. The abrasion of surfaces is performed either by a toothed tool, as in filing, rasping, &c. or by a grinder, in which cutting or hard particles are bedded with considerable firmness in a softer mass; or by scouring, polishing, &c. in which hard particles are more or less slightly retained in a soft or tenacious substance.

Mr. Cumberland's instruments appear to promise great utility in the first and last of these processes; that is, they may be used either with or without a fretting powder. There are however many objections to their being used to grind speculums; not only with regard to the intended figure, but the nature of the material.

WILLIAM NICHOLSON.

No. 78.

Researches respecting the Composition of Enamel. By C. CLOUET, *Associate of the French National Institute.**

WHITE ENAMEL.

WHITE enamel, either for earthen-ware, or the purpose of being applied on metals, is composed in the following manner: You first calcine a mixture of lead and tin, which may be varied in the following proportions; viz. for 100 parts of lead, 15, 20, 30, and even 40 of tin. A mixture of lead and tin calcines very easily in contact with the air. As soon as this mixture is brought to a red heat, nearly a cherry colour, it burns like charcoal, and is calcined very speedily. The composition which calcines best, is that which in 100 pounds of lead contains from 20 to 25 of tin. The tin here meant is pure tin. In proportion as the calcination is effected, you must take out the calcined part, and continue to oxydate the rest until the whole has become pulverulent. As some small particles always escape calcination, you must expose to the fire a second time the oxyd obtained in order to calcine it completely; which may be easily known by its

* Tilloch, vol. 7, p. 3. From the *Annales de Chimie*.

ceasing to sparkle; that is to say, when you no longer see any parts burn like coal, and when the whole appears of an uniform colour. When the proportion of tin exceeds 25 or 30, a stronger fire is necessary to produce the calcination. In a word, by varying the degrees of heat you will be able to discover that best suited to the mixture on which you operate.

A hundred parts of the calx above mentioned, which in the French potteries is called *calcine*, is generally taken with 100 parts of sand. From 25 to 30 pounds of sea-salt, or muriat of soda, are added: the whole is well mixed together, and it is fused in the bottom of a furnace in which potter's ware is baked. This matter is generally placed on sand, on lime quenched in the open air, or on ashes. The bottom of the mass is in general badly fused. This, however, does not prevent the matter, after it has been pounded, and applied on the articles, from becoming exceedingly white and hard in the furnace. When taken from the furnace it is not white; it is even often very black: in general it is marbled with black, gray, and white.

This process is that generally used in potteries. In the compositions destined for earthen-ware, the proportion of 25 parts of tin to 100 of lead is never exceeded: for common earthen-ware, the manufacturers are even satisfied with 15 of tin to 100 of lead. It may be easily seen, that if you wish to obtain an enamel whiter and more fusible, you must diminish the quantity of sand; but there is no necessity for augmenting that of the sea-salt, or muriat of soda: as the whiteness and opacity depend on the quantity of tin, you may use *calcine*, which contains 25 or 30 per cent. For example, 100 of such calcine, 60 of sand, and 25 of marine salt, give a composition exceedingly fusible.

But it is to be observed, that it is necessary to employ some further manipulations when you wish to have enamel proper for being applied on metal, and are desirous to give it all the perfection of which it is susceptible. In that case, you do not employ crude sand, but calcine it, in a strong heat, with a quarter of its weight of marine salt, either in a small quantity in a crucible, or on a large scale in a potter's furnace. If you wish to have a very fusible enamel, you may even add minium, or lead calcined by the former operation, and nearly as much sea-salt, that is to say, a fourth. You then obtain a white mass half fused and porous, which you pulverise, and employ in the composition of enamel instead of sand, and in the same proportions as sand: you may even diminish the quantity of this matter to 50 per cent, if you are desirous to obtain an enamel very fusible. This will depend also on the *calcine* employed; for that which is most charged with tin is the least fusible.

When you wish to have fluxes for the colours, you employ the same compositions before mentioned, except that you put little or no tin into the lead. In the latter case you must generally employ minium. This flux is good for certain colours, but not for all. There are some which become tarnished by fluxes, that contain the oxyds of lead. In that case, you must make fluxes without oxyd of lead. Nitre and borax are generally used for making this glass, but you add no calx of tin. The following are those which I have tried:

Three parts of siliceous sand, one of chalk, and three of calcined borax, give a matter proper to be used as a flux for purples, blues, and other delicate colours.

Three parts of white or flint glass, one of calcined borax, a quarter of a part of nitre, one of the white oxyd of antimony made with nitre well washed, give an exceed-

ingly white enamel, which may serve also as a flux for purple, and particularly for blue.

Sixty parts of enamel sand or less, thirty of alum, thirty-five of sea-salt, and a hundred of minium, or any other oxyd of lead, give a white enamel when the fluxes do not predominate too much, and a gelatinous glass when a great deal of fluxes has been added. This glass is good for red, and the enamel may be applied to all kinds of clay capable of sustaining a strong heat.

It is of great importance to remark, and to know, that the sand employed for enamel must not be sand which contains only silex: sand of that kind alone is of no use. The sand proper for this purpose is that which contains talc with silex. To make a sand proper for enamel and the fluxes of colours, &c. there must be nearly one part of talc and three of siliceous sand.

What appears to me most essential in regard to the success of enamel, is the choice of sand. It is very possible to compose this sand by art; and though I have not decomposed it, I have found by synthesis, that three parts of siliceous sand and one of talc form an excellent sand for enamel. From this it may be readily seen, that, to compose with facility sand for enamel, nothing is necessary but to determine, by a good analysis, the quantity of talc. This sand may be procured in places where earthen-ware is made. It may be easily known; for, besides the siliceous sand, which forms the greatest part of it, you may observe in it talcky particles in great abundance; and, to be good, it must contain nearly a quarter. When it does not contain a sufficient quantity, the enamel it produces fuses with more difficulty, and does not become smooth; it remains granulated and pitted. There are certainly some combinations of earth which may produce very good fluxes, either for enamel or for transpa-

rent colours. It might be attended with advantage to try some of these combinations. Ponderous earth (barytes) and lime fuse very well together: by adding a little silex, or a little magnesia, it is probable that an excellent matter might be produced. If this glass, composed of lime and barytes only, had sufficient solidity to resist the air and weak acids, there would be no necessity perhaps to add silex; but if the marine salt, as I am inclined to think, ought also to enter into the composition of this kind of glass, silex ought likewise to form a part of it. The experiments on this head, for the sake of trial, may be varied different ways. When the glass destined to serve as flux for colours is employed, it is customary, in order that they may be rendered more fusible, to add a little nitre and borax. The common borax of the shops contains an excess of soda, which, in my opinion, it would be of benefit to saturate with the nitric acid. I think also that the flux might be rebaked with the dose of nitre and borax, or of nitric borax, which might be added before being employed. It is only to colours such as purple and the oxyd of cobalt that nitre and borax are added.

I have tried to find a substitute for marine salt in the composition of white enamel. Potash produced only an ugly and ill fused gray mass, which acquired no lustre in the furnace; nitre produced a green mass, but exceedingly friable; sulphat of potash produced very nearly the same effect, only the mass was a little whiter: but neither of these enamels was worth any thing. I did not try pure soda: I have, however, heard common soda extolled; but as it contains a great deal of marine salt, it must undoubtedly be on account of this salt that it produces a good effect. Pure soda may nevertheless be tried, either alone or with marine salt; it perhaps might produce no bad effect with potash.

I have tried also a mixture of equal parts of lime and argil, to which I added one part of silex, and likewise without silex; but this mixture did not supply the place of talcky sand. This sand is not in general found in grains; it exhibits itself most commonly under the form of a stone, such as free-stone; but some of it is found also in grains.

We should be much deceived in making white enamel were we to employ the oxyds of tin and lead separately, as I have read in all the authors I could find who treat on the art of pottery. None of them say what they ought respecting enamel, nor even respecting the composition or nature of the earth proper for bearing an enamel.

It is essential that the lead and tin for making the oxyd employed to produce white enamel, should be fused and mixed together before they are calcined; and if you wish that the enamel should immediately acquire its full whiteness, it will be necessary that the calcination should be complete.

Bismuth might perhaps be employed as a substitute for the lead, and it is not improbable that it would give a good effect. Bismuth also might be mixed with the lead in the following manner; namely, one part of lead, one of bismuth, and one of tin: or other proportions might be employed; but I have not tried any others. As the oxyd of bismuth, however, is exceedingly fusible, I think it might be admitted, with great advantage, into certain fluxes. I have not tried what might be produced by the white calx of zinc, nor by that of tin, made by dissolving it in the nitric acid or by detonation with nitre. A mixture of lead and tin, detonated with nitre, would be useful. Though the white calx of regulus of antimony made by nitre, and well washed, (diaphoretic antimony,) produces a very beautiful white enamel when fused with

three parts of white glass, (which contains neither lead nor other metallic oxyds,) and one of glass of borax, with a half or fourth part of nitre; yet this calx, so white when mixed with the composition of enamel, made with enamel sand and the combined oxyd of lead and tin, instead of increasing, tarnishes the whiteness, and only gives a blueish enamel of a livid colour.* Perhaps enamels, completely made and mixed together in the first instance, would not produce the same effect; but this I never tried. I have, however, employed this composition as a flux for colours, which, applied afterwards on the enamel of earthen-ware, preserved its beauty. I put some of this pure enamel also over that of earthen-ware, and I think it preserved its whiteness.

The principal quality of good enamel, and that which renders it fit for being applied on baked earthen-ware, or on metals, is the facility with which it acquires lustre by a moderate heat, (a cherry-red heat, more or less, according to the nature of the enamel,) without entering into complete fusion.† Enamels applied to earthen-ware and metals possess this quality. They do not enter into complete fusion; they assume only the state of paste, but of a paste exceedingly firm; and yet when baked one might say that they had been completely fused.

There are two methods of painting on enamel: on raw or on baked enamel. Both these methods are employed, or may be employed, for the same object. Solid colours, capable of sustaining the fire necessary for baking the enamel ground, may be applied in the form of fused ena-

* Antimony, employed in any manner as a glazing for earthen-ware, would be more dangerous than lead; even the latter should, if possible, be discarded.—TILLOCH.

† The ingenious author has omitted another principal quality. It ought never to contain such a portion of deliquescing salts, as to endanger its being afterwards injured by water. This takes place oftener than is generally suspected.—TILLOCH.

mel on that which is raw, and the artist may afterwards finish with the tender colours. The colours applied on the raw material do not require any flux; there is one, even, to which silex must be added, that is, the calx of copper, which gives a very beautiful green: but when you wish to employ it on the raw material, you must mix with it about two parts of its weight of silex, and bring the mixture into combination by means of heat. You afterwards pulverise the mass you have thus obtained, in order to employ it.

To obtain good white enamel, it is of great importance that the lead and tin should be very pure. If these metals contain copper or antimony, as is often the case, the enamel will not be beautiful: iron is the least hurtful.

Of Coloured Enamels.

All the colours may be produced by the metallic oxyds. These colours are more or less fused in the fire, according as they adhere with more or less strength to their oxygen. All metals which readily lose their oxygen cannot endure a great degree of heat, and are unfit for being employed on the raw material.

Purple.

This colour is the oxyd of gold, which may be prepared different ways; as by precipitating, by means of a muriatic solution of tin, a nitro-muriatic solution of gold much diluted in water. The least quantity possible of the solution of tin will be sufficient to form this precipitate. The solution of tin must be added gradually until you observe the purple colour begin to appear: you then stop; and having suffered the colour to be deposited, you

put it into an earthen vessel to dry slowly.* The different solutions of gold, in whatever manner precipitated, provided the gold is precipitated in the state of an oxyd, give always a purple colour, which will be more beautiful in proportion to the purity of the oxyd; but neither the copper nor silver, with which gold is generally found alayed, injure this colour in a sensible mnnner: it is changed, however, by iron. The gold precipitate which gives the most beautiful purple is certainly fulminating gold, which loses that property when mixed with fluxes. Purple is an abundant colour; it is capable of bearing a great deal of flux, and in a small quantity communicates its colour to a great deal of matter. It appears that saline fluxes are better suited to it than those in which there are metallic calces. Those, therefore, which have been made with silex, chalk, and borax, or white glass, borax, and a little white oxyd of antimony, with a little nitre, as I have already mentioned, ought to be employed with it. Purple will bear from four to twenty parts of flux, and even more, according to the shade required. Painters in enamel employ generally for purple a flux which they call brilliant white. This flux appears to be a semi opake enamel, which has been drawn into tubes, and afterwards blown into a ball at an enameller's lamp. These bulbs are afterwards broken in such a manner that the flux is found in small scales, which appear like the fragments of small hollow spheres. Enamel painters mix this flux with a little nitre and borax. This matter, which produces a very good effect, I employed, without attempting to decompose it. It may be a very fusible common white enamel which has been blown into that form. It is to be remarked, that purple will not bear a strong heat.

* The colour is always more beautiful, if the precipitate is ground with the flux before it has become dry.—TILLOCH.

Red.

We have no metallic oxyd capable of giving directly a fused red; that is to say, we have no metallic calces which, entering into fusion, and combining under the form of transparent glass with fluxes or glass, give directly a red colour. To obtain this colour it must be compounded different ways, as follows:—Take two parts, or two parts and a half (you may, however, take only one part,) of sulphat of iron and of sulphat of alumine; fuse them together in their water of crystallisation, and take care to mix them well together. Continue to heat them to complete dryness; then increase the fire so as to bring the mixture to a red heat. The last operation must be performed in a reverberating furnace. Keep the mixture red until it has every where assumed a beautiful red colour, which you may ascertain by taking out a little of it from time to time, and suffering it to cool in the air. You may then see whether the matter is sufficiently red: to judge of this it must be left to cool, because while hot it appears black. The red oxyds of iron give a red colour; but this colour is exceedingly fugitive; for, as soon as the oxyd of iron enters into fusion, the portion of oxygen which gives it its red colour leaves it, and it becomes black, yellow, or greenish. To preserve, therefore, the red colour of this oxyd in the fire, it must be prevented from vitrifying, and abandoning its oxygen; which may be accomplished by the method I have indicated. I have tried a variety of different substances to give it this fixity, but none of them succeeded except alum. The doses of alum and sulphat of iron may be varied. The more alum you add, the paler will be the colour. Three parts of alum to one of sulphat of iron give a colour which approaches flesh colour. It is alum also which gives this colour the property of becoming fixed at a very strong

heat. This colour may be employed on raw enamel: it has much more fixity than the purple, but not so much as the blue of cobalt. It may be washed to carry off the superfluous saline matter, but it may be employed also without edulcoration; in that state it is even more fixed and more beautiful. It does not require much flux; the flux which appeared to me to be best suited to it, is composed of alum, minium, marine salt, and enamel sand. This flux must be compounded in such a manner as to render it sufficiently fusible for its object: from two to three parts of it are mixed with the colour. In general, three parts of flux are used for one of colour: but this dose may, and ought to be varied according to the nature of the colour and the shade of it required. Red calx of iron alone, when it enters into fusion with glass, gives a colour which seems to be black; but if the colour be diluted with a sufficient quantity of glass, it at last becomes of a transparent yellow. Thus, the colour really produced by calx of iron combined with glass is a yellow colour, but which being accumulated becomes so dark that it appears black. In the process above given for making the red colour, the oxyd of iron does not fuse: and this is the essential point; for, if this colour is carried in the fire to vitrification, it becomes black, or yellowish, and disappears if the coat be thin, and the oxyd of iron present be only in a small quantity.

Yellow.

Though yellow may be obtained in a direct manner, compound yellows are preferred; because they are more certain in their effect, and more easily applied than the yellow, which may be directly obtained from silver. The compound yellows are obtained in consequence of the same principles as the red colour of iron. For this purpose we employ metallic oxyds, the vitrification of which

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(Concluded from page 400.)

A YELLOW may be obtained also directly from silver. All these mixtures may be varied, and you may try others. For this purpose you may use sulphat of silver, or any oxyd of that metal mixed with alumine or silex, or even with both, in equal quantities. The whole must be gently heated until the yellow colour appear, and the matter is to be employed with the fluxes pointed out for yellows. Yellow of silver, like purple, cannot endure a strong heat: a nitric solution of silver may be precipitated by the ammoniacal phosphat of soda, and you will obtain a yellow precipitate, which may be used to paint in that colour with fluxes, which ought then to be a little harder.

Besides the methods above mentioned, the best manner of employing the oxyd of silver is, in my opinion, to employ it pure: in that case, you do not paint, but stain. It will be sufficient, then, to lay a light coating on the